induced die-off estimated at 344 wild adult coho salmon, 629 steelhead trout, and 33,527 adult Chinook salmon (Guillen 2002, 2003). Since this time poor water quality has also been implicated in increasing juvenile susceptability to native pathogens and is thought to be the cause significant juvenile outmigrant mortalities as well.

3.4.2.5 Coastal Cutthroat Trout

Distribution. Coastal cutthroat trout are found in coastal drainages from the Eel River in northern California (Dewitt, 1954) to Prince William Sound in Alaska (Trotter, 1989). The inland limits of coastal cutthroat trout distribution are most likely the Fraser River in British Columbia and Celilo Falls on the Columbia River (Crawford, 1979; Trotter, 1989).

Status of Populations. NMFS determined that listing was not warranted for the Southern Oregon/California Coasts coastal cutthroat trout ESU (April 5, 1999, 64 FR 16397). This species is now formally under the jurisdiction of the USFWS. The USFWS is currently reviewing the status of cutthroat trout. Coastal cutthroat trout are a CDFG species of special concern and a USFS sensitive species (CDFG, 2001). All populations of coastal cutthroat trout in California are considered by some biologists to be at a moderate risk of extinction (Nehlsen et al., 1991).

Life History and Habitat Requirements. Coastal cutthroat trout can exhibit resident freshwater and anadromous life history forms, as indicated in the summary of key life history characteristics (Table 3.4-2). Resident populations spawn in the spring or early summer, with young fish emerging from the gravels from late spring through summer. Adults and juveniles use stream riffles and pool habitat for feeding and cover, respectively, and primarily pools and deep water habitat during winter. The resident form feeds primarily on aquatic insects, as opposed to the piscivorous (fish-eating) anadromous form (Wydoski and Whitney, 1979).

Anadromous coastal cutthroat trout exhibit a much different and more complex life history pattern than residents, because of their movements between freshwater and saltwater systems. The anadromous form spawns in smaller headwater streams and tributaries of coastal rivers to which they have access (Wydoski and Whitney, 1979). Spawning occurs primarily from late December to February, and young emerge from the gravels about mid-May. They remain in their natal streams for about a year before moving downstream to larger streams where they can live for 1 to 6 years. The anadromous form is quite piscivorous while rearing in freshwater (Behnke, 1992). Most outmigration to the ocean occurs from April through June (Wydoski and Whitney, 1979).

The life history and habitat requirements of coastal cutthroat while in saltwater are relatively unknown (Wydoski and Whitney, 1979). They do not appear to migrate to the open ocean, but instead use bays, estuaries, and the coastline where they feed on crustaceans and fish (Behnke, 1992).

Factors Affecting Populations. Behnke (1992) states that numbers of coastal cutthroat trout have drastically declined in many areas because of environmental alterations (mainly logging practices that result in increased sedimentation, reduced cover, and increased stream temperatures) and hybridization with non-native trout species. The NMFS and USFWS joint proposed rule for coastal cutthroat trout (April 5, 1999, 64 FR 16397) states that the present or threatened destruction, modification, or curtailment of its habitat or range;

overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; and other natural or manmade barriers affecting its continued existence are the principle factors for decline across the range of coastal cutthroat trout.

3.4.2.6 Steelhead (Northern California DPS and Klamath Mountains Province ESU) and Resident Rainbow Trout

Distribution. Coastal rainbow trout are widely distributed from the Kuskokwin River in western Alaska to Baja California (Moyle, 1976; Behnke, 1992). Steelhead (the anadromous form) occur throughout the range of coastal rainbow trout except in the northern and southern extremities (Behnke, 1992). The present southern limit of steelhead distribution is Malibu Creek, California.

Status of Populations. Rainbow trout, the resident form, are under the jurisdiction of the USFWS and are currently unlisted. NMFS published a proposed rule to list steelhead in the Klamath Mountains Province ESU as threatened (March 16, 1995, 60 FR, 14253). NMFS subsequently determined that listing was not warranted for this ESU (March 19, 1998, 63 FR 13347). However, NMFS reproposed the Klamath Mountains Province steelhead ESU for listing as a threatened species because of concerns over specific risk factors (February 12, 2001, 66 FR 9808). It was subsequently determined that listing of the Klamath Mountains Province steelhead ESU was not warranted (April 4, 2001, 66 FR 17845). The Klamath Mountains Province steelhead ESU includes steelhead from the Elk River in Oregon to the Klamath and Trinity Rivers in California, inclusive, overlapping the Primary Assessment Area.

NMFS listed the Northern California steelhead as a threatened species on June, 7, 2000, (65 FR 36074) and reaffirmed its threatened status and converted its ESU designation a DPS on Jan 5, 2006 (71 FR 834). The Northern California steelhead DPS includes all naturally spawned steelhead populations below natural and manmade impassable barriers in California coastal river basins from Redwood Creek southward to, but not including, the Russian River. This DPS also includes two artificial propagation programs: the Yager Creek Hatchery and the North Fork Gualala River Hatchery. Critical Habitat for Northern California steelhead was designated on September 2, 2005, (70 FR 52488) and includes numerous river reaches and estuarine areas from Redwood Creek south to, but not including, the Russian River. These reaches and areas were identified through a process that considered historic and current utilization, current habitat quality, unique watershed and reach characteristics, the potential for restoration of degraded habitat, and the coextensive economic impacts associated with designation. The Northern California steelhead DPS and its associated critical habitat overlap the Primary Assessment Area. The location of steelhead ESUs/DPSs in the vicinity of the Green Diamond ownership is shown on Figure 3.4-3.

Summer-run steelhead from the Klamath Mountains Province ESU and the Northern California DPS are on CDFG's list of species of special concern (CDFG, 2001). Currently, all runs of steelhead within this species' southern limits (Malibu Creek, Santa Clara River, Ventura River, and Santa Ynez River) are considered at a high risk of extinction by many fisheries biologists (Nehlsen et al., 1991).

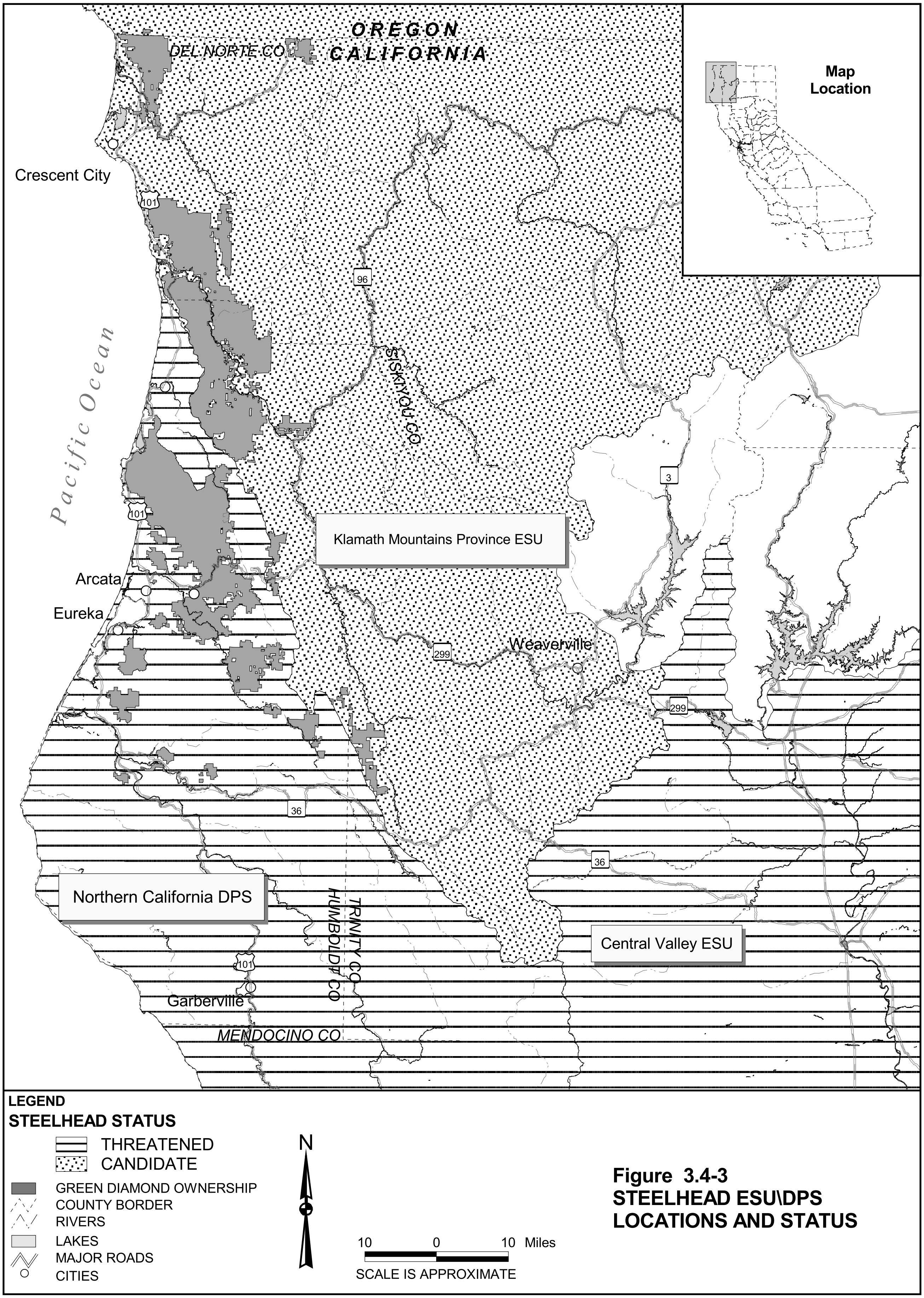

Figure 3.4-3
STEELHEAD ESU\DPS LOCATIONS AND STATUS

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Life History and Habitat Requirements. Rainbow trout can exhibit resident freshwater and anadromous life history forms, as indicated in the summary of key life history characteristics in Table 3.4-2. Resident populations spawn from late summer through spring, with young fish emerging from the gravels in the spring and early summer. Steelhead (the anadromous form) generally rear for 2 years in freshwater before migrating to the ocean, where they typically spend two years before returning to freshwater to spawn. However, some individuals may spend 1 to 4 years at sea before reaching sexual maturity. Although steelhead are anadromous, they display different life history strategies than salmon. The most significant difference is that some steelhead survive spawning, return to the ocean for 1 or more years, then return to spawn again. Salmon only spawn once, then die.

Steelhead consist of two reproductive types, based on (1) sexual maturity at the time they enter rivers for spawning, and (2) duration of their spawning migration (Busby et al., 1996). Stream-maturing steelhead are sexually immature when they enter freshwater rivers and require several months to mature and spawn. These fish are known as summer steelhead. The other type are ocean-maturing fish, which enter rivers sexually mature and spawn shortly after entering freshwater. These steelhead are referred to as winter steelhead.

Summer run steelhead are able to use habitat not accessible to fall/winter-run salmonids (Busby et al., 1996). Summer steelhead enter freshwater between May and October. Winter steelhead enter freshwater between November and April. Steelhead in the Primary Assessment Area spawn from September to March, depending on the time of entry. Redds are constructed in areas of coarse gravel and cobbles. Fry emergence occurs in late spring. Freshwater residence varies from 1 to 4 years, but 1 to 2 years is predominant in the Primary Assessment Area. Rearing steelhead tend to inhabit riffles and higher gradient habitats. Densities of juvenile steelhead in streams are greatest where there are good amounts of instream cover (Stoltz and Schnell, 1991).

The anadromous (steelhead) and resident (rainbow trout) forms are genetically indistinguishable, and the life history and habitat requirements of resident rainbow trout are similar to those of steelhead while in the freshwater phase (with the possible exception of estuary and some mainstem habitats). Table 3.4-2 summarizes key life history and habitat requirements for steelhead and rainbow trout.

Factors Affecting Populations. NMFS concluded that all of the factors identified in Section 4(a)(1) of the ESA have played a role in the decline of steelhead. Destruction and modification of habitat, overutilization for recreational purposes, and natural and human-caused effects are listed as the primary reasons for the decline of west coast steelhead populations (March 16, 1995, 60 FR 14253).

Steelhead populations have declined in abundance over the past several decades because of natural and human factors. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. Water diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat. Loss of habitat complexity also has contributed to steelhead declines. Sedimentation from land use activities is a primary cause of habitat degradation in the range of west coast steelhead (Busby et al., 1996).

Steelhead support an important recreational fishery. During times of decreased habitat availability (for example, during summer low flows when fish are concentrated), the impacts of recreational fishing on native anadromous stocks may increase. Incidental harvest mortality in mixed-stock sport and commercial fisheries may exceed 30 percent of listed populations. In addition, introduced non-native species and habitat modifications have led to increased predator populations in numerous river systems, and increased the level of predation on steelhead (Busby et al., 1996).

NMFS identified several factors they considered to have contributed to the decline of the Northern California steelhead DPS. These factors include impacts from historic flooding, predation, water diversions and extraction, minor habitat blockages, poaching, timber harvest, agriculture, and mining. These human-induced impacts in the freshwater ecosystem have likely reduced the species' resiliency to natural factors for decline, such as drought and poor ocean conditions (February 11, 2001, 65 FR 6960). Of recent note, poor water quality conditions in the Klamath River system in 2002 resulted heightened physiological stress on returning adult salmon, resulting in a significant disease induced die-off estimated at 344 wild adult coho salmon, 629 steelhead trout, and 33,527 adult Chinook salmon (Guillen 2002, 2003). Since this time poor water quality has also been implicated in increasing juvenile susceptability to native pathogens and is thought to be the cause significant juvenile outmigrant mortalities as well.

3.4.2.7 Tidewater Goby

Distribution. The tidewater goby is endemic to California and discontinuously distributed along the coast from Agua Hedionda Lagoon, in San Diego County, north to the mouth of the Smith River in Del Norte County (Moyle et al., 1995).

Status of Populations. The tidewater goby has been extirpated from nearly 50 percent of the lagoons within its historic range and faces threats indicating that this downward trend is likely to continue. The tidewater goby was listed as endangered under the Federal ESA in 1994 (March 7, 1994, 59 FR 5494).

Life History and Habitat Requirements. The tidewater goby is found in shallow lagoons and lower stream reaches where waters are brackish to fresh and fairly slow moving. They avoid areas of strong current and wave action. Although its closest relatives are marine species, the tidewater goby lacks a marine life history phase. All life stages of tidewater gobies are found at the upper end of lagoons in salinities less than 10 parts-per-thousand. This species occurs in loose aggregations on the substrate in shallow water less than 3 feet deep. Eggs are deposited in vertical burrows excavated in clean, coarse sand. Larval gobies are found midwater around vegetation until they become benthic and begin feeding on small invertebrates and insect larvae.

Factors Affecting Populations. Coastal development projects that result in the loss of critical saltmarsh habitat are currently the major factor adversely affecting the tidewater goby (December 11, 1992, 57 FR 58770). Other factors contributing to the decline of the population include predation by exotic species and drought conditions combined with human-induced water reductions.

3.4.2.8 Southern Torrent Salamander

Distribution. The southern torrent salamander is one of four species in the genus *Rhyacotriton* and is the most southerly ranging. It is the only species of this genus that occurs in California. Southern torrent salamanders occur within the coastal conifer forest belt of northern California and southern Oregon, specifically from southern Mendocino County, California through the Coast Ranges, to the Little Nestucca River and the Grande Ronde Valley in Polk, Tillamook, and Yamhill Counties (Good and Wake, 1992). In California, this species is found in the coastal forests of northwestern California south to Mendocino County (Anderson, 1968). Bury and Corn (1988a) believed that these salamanders are distributed as isolated, discrete populations, especially in heavily managed or drier forests.

Status of Populations. On June 6, 2000, USFWS announced that, after review, the southern torrent salamander did not warrant listing as endangered or threatened. However, USFWS recommended that the species remain on the Federal species of concern list.

The southern torrent salamander was a candidate for State listing as a threatened species. However, the California Fish and Game Commission ruled that this petition was not warranted and that CDFG should continue to consider the species as a species of special concern.

Life History and Habitat Requirements. Southern torrent salamanders have very specific habitat requirements of cold, shallow, flowing headwaters in humid coniferous forests (Nussbaum and Tait, 1977; Nussbaum et al., 1983; Diller and Wallace, 1996; Welsh and Lind, 1996). They are found most frequently in seeps, springs, and intermittent streams (Welsh, 1993) or in shallow water seeping through moss-covered gravel (Nussbaum et al., 1983). They appear to avoid open deep-water channels (Stebbins, 1985; Welsh, 1993). Adults are semiaquatic and are found next to larvae in streams, or under rocks or debris in saturated streamside habitats; larvae are aquatic and usually occur in loose gravel in streambeds (Nussbaum and Tait, 1977; Nussbaum et al., 1983). Southern torrent salamanders rarely move far from moist areas as they are very sensitive to dessication. Riparian areas are thought to be important to the species for foraging (Corn and Bury, 1989) and for courtship and reproduction (Nussbaum et al., 1983). Shade and high surface water availability are needed for movement within riparian areas. Table 3.4-3 summarizes key life history and habitat requirements for this species.

Factors Affecting Populations. The petition to list the southern torrent salamander cited habitat fragmentation, population declines, and inhibited dispersal capability throughout the species' range as significant threats to the species. Evidence indicates that timber harvesting and road building can negatively affect habitat for the southern torrent salamander. Direct effects of these activities include disturbance of substrate and killing of individual salamanders. Indirect effects include sedimentation of substrate used by the salamanders, increases in water temperatures to lethal levels, potential loss of permanent water flow, and potential increases in predator populations. The species' long lifespan may enable it to persist in marginal habitats until conditions improve. Southern torrent salamanders may also be able to burrow vertically in the substrate to find moist, cool conditions.

3.4.2.9 Tailed Frog

Distribution. The tailed frog is the only member of the genus *Ascaphus.* It is endemic to the Pacific Northwest and is widely distributed from northwestern California to British Columbia and western Montana (Nussbaum et al., 1983). Tailed frogs are found at elevations from sea level to near timber line throughout the coastal mountains from British Columbia south to Mendocino County and in the inland mountains of southeast Washington, Idaho, and Montana (Metter, 1968). In California, they occur from sea level to 6,500 feet elevation, mostly at sites receiving more than 40 inches of precipitation annually in Siskiyou, Del Norte, Trinity, Shasta, Tehama, Humboldt, Mendocino, and possibly Sonoma Counties (Bury, 1968). Throughout much of its range the species is distributed as disjunct populations (Metter, 1968). Bury and Corn (1988a) believed that isolated, discrete populations most likely occurred in drier forests and heavily managed lands.

Status of Populations. It currently is a Federal species of concern and a CDFG species of special concern.

Life History and Habitat Requirements. Tailed frogs are found in and along small, swift, permanent, mountain streams with rocky substrates and low water temperatures buffered by dense vegetation (Nussbaum et al., 1983; Reichel and Flath, 1995; Daugherty and Sheldon, 1982). Streams supporting tailed frogs primarily occur in mature (Aubry and Hall, 1991) or old-growth coniferous forests (Bury, 1983; Bury and Corn, 1988a). More tailed frogs were observed in older Douglas fir-dominated, mixed conifer/hardwood forests near cold, clear, fast-flowing streams than in younger forests with the same type streams (Welsh, 1990). In the Coast Range of western Oregon, Corn and Bury (1989) found tailed frogs were more common in dense, moist, and young and mature forests, and absent from recent clearcuts. Tailed frogs tend to avoid wetlands, marshes, ponds, lakes, and slow, sandy-bottom streams (Daugherty and Sheldon, 1982). Table 3.4-3 summarizes key life history and habitat requirements of tailed frogs.

Factors Affecting Populations. Tailed frogs were considered rare for many years, but are now known to occur in high densities in suitable habitats (Nussbaum et al., 1983). Bury and Corn (1988a) and Welsh (1990) believed that long-term, range-wide reductions or extinctions of tailed frogs were likely caused by local extirpations, increased population fragmentation, habitat loss, restricted gene flow, and limited recolonization of streams when habitats are re-established. Although the survival of tailed frogs may depend on protection of cool flowing streams and adjacent forest habitats (Bury and Corn, 1988b), timber harvesting is not incompatible with such protection (Welsh, 1990). Bury and Corn (1988a) recommended establishing protection zones for tailed frogs by retaining deciduous and small (cull) trees around streams while felling merchantable timber away from the streams.

3.4.2.10 Foothill Yellow-Legged Frog

Distribution. The foothill yellow-legged frog is found west of the Oregon Cascades and south to Baja California, Mexico. Historically, this species was known to occur in most Pacific drainages from the Santiam River system in Oregon to the San Gabriel River system in Los Angeles County, California (Jennings and Hayes, 1994). In California, the foothill yellow-legged frog was historically distributed throughout the foothills of most drainages from the Oregon border to the San Gabriel River. This species is currently found throughout the northern and central Coast Ranges and Sierra Nevada foothills (Jennings and Hayes, 1994).

Status of Populations. The foothill yellow-legged frog has become absent from many locations where it was historically present in the Sierra Nevada foothills and southern portions of its range. The species is still abundant in many drainages in northwestern California and appears to still be distributed throughout its historic range. Jennings and Hayes (1994) described this species as endangered in central and southern California south of the Salinas River; threatened in the west slope drainages of the Sierra Nevada and southern Cascade Mountains east of the Sacramento and San Joaquin Rivers; and of special concern in the Coast Ranges north of the Salinas River. The foothill yellow-legged frog is considered a species of special concern and is fully protected by the State of California. This species also is a Federal species of concern and is considered a sensitive species by the USFS.

Life History and Habitat Requirements. This species is typically associated with valley-foothill hardwood, valley-foothill hardwood-conifer, valley-foothill riparian, ponderosa pine, mixed conifer, coastal scrub, mixed chaparral, and wet meadow habitat types (Zeiner et al., 1988). Foothill yellow-legged frogs are closely confined to the vicinity of permanent streams (Leonard et al., 1993) and intermittent streams (Hayes and Jennings, 1988). Shallow streams with a rocky substrate (at least cobble size) are preferred (Hayes and Jennings, 1988). Within streams with these characteristics, foothill yellow-legged frogs prefer riffles to other stream habitats (Hayes and Jennings, 1988). Foothill yellow-legged frogs appear to prefer streams with partial shading, often avoiding streams with very high (i.e., greater than 90 percent) or very low (i.e., less than 2 percent) stream shading (Hayes and Jennings, 1988). Females attach eggs to cobbles and boulders in shallow water where the eggs survive better than those laid in narrower and deeper channels. Kupferberg (1996) reported that most breeding sites were used repeatedly from year to year.

Factors Affecting Populations. The reduction in this species' distribution has been attributed primarily to dam building and flood control, mining, farming and canal building, urbanization (Jennings, 1988), and the introduction of aquatic predators (i.e., various fishes and bullfrogs) (Jennings and Hayes, 1994).

3.4.2.11 Northern Red-Legged Frog

Distribution. The northern red-legged frog is found in California, Oregon, Washington, and Canada (Nussbaum et al., 1983; Leonard et al., 1993). In California, this subspecies of red-legged frog is found west of the Cascade crest and as far south as Humboldt County. Northern red-legged frog and populations intermediate between northern and California red-legged frogs extend from Marin County north to the California/Oregon border (Jennings and Hayes, 1994).

Status of Populations. Declines in northern red-legged frog populations have been reported in British Columbia, Washington, and Oregon (Jennings and Hayes, 1994). Sufficient information has not yet been collected in California to assess overall population trends (Jennings and Hayes, 1994). The northern red-legged frog is considered a species of special concern and is fully protected by the State of California. This species also is a Federal species of concern and is considered a sensitive species by the USFS.

Life History and Habitat Requirements. Most red-legged frogs are found in moist or wet forest areas and riparian habitats below 2,800 feet (Nussbaum et al, 1983), but they have been reported up to 4,680 feet (Leonard et al., 1993). During the non-breeding season, the red-legged frog is highly terrestrial and can be found up to 1,000 feet from water (Nussbaum et al., 1983). The red-legged frog feeds almost exclusively on land, along the water's margin, and in the vegetation (Licht, 1986), but it typically breeds in marshes, bogs, ponds, lakes, and slow-moving streams with dense streamside vegetation (Stebbins, 1972; Leonard et al., 1993). Studies by Aubry and Hall (1991) and Corn and Bury (1989) have shown the highest abundance in mature forest, with lower numbers in old-growth forest, young forest, and clearcuts. In addition, Aubry and Hall (1991) found positive correlations between red-legged frog abundance and the density of broadleaf trees and percent cover of mid-canopy broadleaf trees.

Factors Affecting Populations. Little information is available concerning the causes for the observed decline of this subspecies, but bullfrog and exotic predatory fish introductions, pesticides, herbicides, coastal development, and timber harvesting have been implicated as contributing factors (Blaustein et al., 1995; Jennings and Hayes, 1994).

3.4.2.12 Western Pond Turtle

Distribution. The western pond turtle historically ranged nearly continuously in most Pacific drainages from Klickitat County, Washington to northern Baja California, Mexico, chiefly west of the Sierra-Cascade crest (Jennings and Hayes, 1994). In California, this species was historically present in most Pacific slope drainages between the Oregon and Mexican borders (Jennings and Hayes, 1994).

Status of Populations. Jennings and Hayes (1994) consider the western pond turtle to be threatened in California and endangered from the Salinas River south along the coast and inland from the Mokelumne River southward. Although the western pond turtle appears to still occur in most areas where it was reported historically, some populations are showing little or no recruitment. Substantial declines in western pond turtle numbers have been reported outside of California (see Jennings and Hayes, 1994). The western pond turtle is considered a species of special concern and is fully protected by the State of California. This species also is considered a Federal species of concern and a sensitive species by the USFS.

Life History and Habitat Requirements. The western pond turtle has been described as an aquatic habitat generalist (Holland, 1991), but within the aquatic habitats used by the turtle, its distribution may vary seasonally and locally. The western pond turtle requires some slack-or slow-water aquatic habitat and inhabits a wide variety of fresh or brackish, permanent or intermittent water bodies. It typically occurs in marshes, lakes, ponds, brackish waters, slow-moving streams and rivers with adjacent vegetation mats, partially submerged logs, boulders, mudflats, and undercut banks and rootwads to serve as either basking or cover habitat (Blaustein et al, 1995). Habitats that lack these refugia are typically avoided by the turtle (Holland, 1994). Aquatic over-wintering sites are found along undercut banks and in soft mud of ponds (Holland, 1994). Western pond turtles can be sensitive to human disturbance, which can affect basking and nesting (Blaustein et al., 1995).

Western pond turtles use terrestrial habitats for nesting and hibernation (Holland, 1994). Mating occurs in April and May, and females move away from watercourses from June through August and migrate upslope to excavate nests up to 1,640 feet from the water's edge (Rathbun et al., 1992). Females are very sensitive to disturbance during this time and may return to the watercourse if disturbed (Holland, 1994). Time spent in terrestrial habitats is variable, varying from locations in southern California where turtles have remained for two to three months to locations in Oregon where turtles have remained at overwintering sites for up to eight months. Overwintering sites generally have been located on slopes less than 35° in duff composed of conifer or broadleaf material (Holland, 1994). Hatchlings may overwinter in nest sites (Rathbun et al., 1992).

Factors Affecting Populations. Agricultural activities, urbanization, flood control, water diversion projects, and introduced predatory fish have contributed to population declines (Jennings and Hayes, 1994). Bullfrogs prey on hatchling and juvenile turtles and bass are known to prey on the smallest juveniles (Jennings and Hayes, 1994). Protection of suitable nesting habitat associated with existing populations and reduction in mortality of the younger age groups of turtles have been recommended to reverse the declining trend observed in western pond turtle populations (Jennings and Hayes, 1994).

3.4.3 Other Aquatic Resources

Other representative groups of aquatic resources present within the Primary Assessment Area and the additional 25,677 rain-on-snow acres under Alternative C besides the fish, amphibian, and reptile covered species described above include the following:

- Other native fish species such as lamprey, sturgeon, suckers, smelt, sculpins, and minnows
- Non-native (introduced) salmonids such as brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and hatchery-reared rainbow trout (*Oncorhynchus mykiss*)
- Non-native, non-salmonids such as sunfishes and bass
- A variety of aquatic invertebrates such as insects, crustaceans, clams, and snails

Numerous interactions can occur among these representative groups under existing conditions. Introduced salmonids can adversely affect some species of native salmonids by competing for space or food, or in some cases by preying on smaller life stages of native salmonids. For example, brook trout and brown trout can potentially compete for food and space with some life stages of native salmonids, and larger brown trout tend to be highly piscivorous in their diet. Native fishes, such as sculpin, provide a food source for native salmonids and introduced salmonids. All native aquatic species, including aquatic invertebrates, which are a major food source for most fish during all or parts of their lives, benefit from the same broad conditions that benefit the covered species. These conditions include cool, clean water and access to complex, diverse habitat.

3.4.4 Aquatic Habitat Conditions

This section provides descriptions of aquatic habitat conditions within the 11 HPAs previously discussed in Sections 3.2, Geology, Geomorphology, and Mineral Resources, and Section 3.3, Hydrology and Water Quality. These descriptions have been summarized from available information on the affected environment presented in Section 4 of Green Diamond's proposed AHCP/CCAA. HPAs encompassing complete drainage areas are referred to as "hydrologic units," whereas those encompassing partial or multiple watersheds are referred to as "hydrographic areas."

In general, the region encompassed by the 11 HPAs is characterized by the following:

- The steep and rugged terrane of the Coast Ranges and Klamath Mountains
- Geologic formations that range in age from pre-Jurassic to Recent and are marked by extensive folds and fault lines
- Several highly unstable geologic formations, including the Franciscan, Wildcat, and Falor formations
- Seasonally intense precipitation
- More than a century of logging, mining, road building, and grazing

Combined, these factors have altered stream conditions and increased hillslope erosion in most coastal watersheds. As a result of excess sedimentation and/or potential temperature concerns in several inland areas, the Klamath River, Redwood Creek, Mad River, Eel River, and Van Duzen River watersheds are included on the Section 303(d) list of impaired watersheds developed by the U.S. EPA and SWRCB (see Table 3.3-2 for a listing of 303(d) listed watersheds and pollutants).

Current habitat conditions and status of AHCP/CCAA covered aquatic species vary by HPA. Water temperatures in the HPAs are described in Section 3.3. Where data are available, current aquatic habitat conditions and status of AHCP/CCAA aquatic species are summarized below for the individual HPAs and the additional rain-on-snow areas outside of the HPAs that would be covered under Alternative C. Occurrence of covered species within the 11 HPAs for all project alternatives is summarized in Table 3.4-4.

3.4.4.1 Smith River Hydrographic Region

Channel and Estuary Conditions. Channel and habitat typing assessments have been conducted on 58 streams throughout the Primary Assessment Area. Four streams were examined within the Smith River Hydrographic Region: Wilson Creek, Dominie Creek, Rowdy Creek, and the South Fork Winchuck River (see Appendix C-1 of the AHCP/CCAA). Partitioning of habitat into pools, riffles, and runs showed a high percentage of riffles on Dominie Creek (51 percent) and the S.F. Winchuck River (41 percent), and a relatively even distribution of habitat types in the other two creeks. Dominie Creek had high levels of pool tailout embeddedness and shallow pool depths, while the other three creeks had low to moderate embeddedness and moderate to deep pools. Canopy density was relatively low on Rowdy Creek (63 percent) and higher on Wilson Creek, Dominie Creek, and S.F.Winchuck River (79 percent to 94 percent). The species composition of the riparian canopy was predominantly deciduous on all streams. Large woody debris (LWD) was not the dominant structural shelter component in any reach within the Smith River Hydrographic Region. Rowdy Creek and S.F. Winchuck River had only 5.6 percent and 6.4 percent LWD as shelter in pools, while Dominie Creek had 18.2 percent and Wilson Creek had 21.8 percent. Long-term channel monitoring is ongoing in two locations within the Smith River Hydrographic Region. Monitoring began on the South Fork Winchuck in 1996 and on Wilson Creek in 1998. No conclusions can be drawn at this point from the monitoring.

TABLE 3.4-4
Occurrence of Species Covered Under Project Alternatives in Hydrographic Planning Areas

Species	Smith River	Coastal Klamath	Blue Creek	Interior Klamath	Redwood Creek	Coastal Lagoons	Little River	Mad River	NF Mad River	Humboldt Bay	Eel River
Fish											
Chinook salmon	K	K	K	K	K	K	K	K	K	K	K
Coho salmon	K	K	K	K	K	K	K	K	K	K	K
Steelhead	K	K	K	K	K	K	K	K	K	K	K
Rainbow trout	K	K	K	K	K	K	K	K	K	K	K
Cutthroat trout	K	K	K	K	K	K	K	K	K	K	K
Tidewater goby	K	P	N	N	P	K			N	K	P
Amphibians and Reptiles											
Tailed frog	K	K	K	K	K	K	K	K	K	K	K
Southern torrent salamander	K	K	K	K	K	K	K	K	K		K
Foothill yellow-legged frog	K	K	K	K	K	K	K	K	K	K	K
Northern red-legged frog	K	K	K	K	K	K	K	K	K	K	K
Western pond turtle	P	K	K	K	K	P	K	K	K	P	P

K Known
P Presumed
N Does not occur
blank unknown

An LWD inventory was conducted in 20 streams throughout the Primary Assessment Area in 1994 and 1995, including four streams within the Smith River Hydrographic Region: Rowdy Creek, Dominie Creek, South Fork Winchuck River, and Wilson Creek (see Appendix C-2 of the AHCP/CCAA). There was a moderate level of both inchannel and recruitment zone LWD, but the size of the in-channel LWD was predominantly small (less than 2 foot diameter), reflecting the alder-dominant riparian zones prevalent throughout the Primary Assessment Area. The lack of large diameter LWD results in low levels of in-channel LWD available to function as shelter or to promote formation of pools. Stream health in the Smith River Hydrographic Region would benefit from increased abundance of large diameter and length LWD.

The Winchuck River estuary has been impacted by a reduction of habitat through channelization for livestock grazing. The mouth of the Winchuck River regularly bars over during the summer to form an enclosed estuary. This estuary is occupied by juvenile Chinook salmon and coastal cutthroat trout during the summer months. The estuary habitat for rearing salmonids is limited because of both a lack of depth and LWD for protective cover and avian predator avoidance. Efforts are underway by the Oregon Department of Fish and Wildlife to enhance the rearing habitat in the Winchuck River estuary.

The lower channel and estuary of the Smith River has been altered and simplified by agriculture, livestock grazing, gravel mining, and urban development. The loss of secondary channels, sloughs, backwaters, and LWD has reduced the amount and complexity of salmonid rearing habitat. The Smith River mouth generally remains open and fails to bar over to form an enclosed estuary.

The lower section of the Wilson Creek watershed lacks an estuary. The creek runs directly into a semi-protected section of coastline where wave action at the creek's entrance is cushioned by exposed rocks. Flow in the lower channel is intermittent during the summer, thus out-migrating salmonid smolts have a discrete window in which to leave the watershed.

Species Status. The Smith River Hydrographic Region is in the Southern Oregon and Northern California Coastal ESU for Chinook salmon, which NMFS determined does not warrant listing (September 16, 1999, 64 FR 50394). Juvenile Chinook production is thought to be increasing in the Winchuck River. The Smith River has the only known spring-run Chinook population in the Northern California Coastal Chinook ESU. Chinook are well distributed in smaller coastal streams in the SONCC Chinook salmon ESU, and recent increases in abundance have been noted in these smaller coastal streams (September 16, 1994, 64 FR 50394).

Coho salmon populations are depressed throughout the SONCC ESU, which includes the Smith River Hydrographic Region. Current abundance in the California portion of this ESU is thought to be less than 6 percent of the abundance in the 1940s (Weitkamp et al., 1995). The SONCC coho salmon ESU was listed as threatened under the ESA on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Spawner surveys and outmigrant trapping on Mill Creek, tributary to the Smith River, indicate that Mill Creek supports an abundant coho run (Howard, unpubl. data). Recent surveys of coho salmon conducted by Green Diamond (both spawner/carcass and juvenile counts) in the South Fork Winchuck River and Wilson Creek indicate that runs in both streams are low and variable. The annual estimate of juvenile coho salmon in Wilson Creek has varied widely from less than 20 to nearly 1,400 juveniles during the 1995-2000 period. Coho estimates in the South Fork Winchuck River have been much lower than those in Wilson Creek over the same period (see Appendix C-7 of the AHCP/CCAA).

The Smith River Hydrographic Region is within the Klamath Mountains Province ESU for steelhead, which was determined to not warrant listing as of April 4, 2001 (66 FR 17845). Steelhead populations in the Winchuck River were assessed as "Healthy" by the Oregon Department of Fish and Wildlife (ODFW)/CDFG (Nickelson et al., 1992). Smith River fall-run steelhead were considered "Healthy" by ODFW/CDFG but summer-run fish were considered at high risk of extinction by Nehlsen et al. (1991) and as depressed by the USFS (from Busby et al., 1994). Annual juvenile steelhead population estimates at Wilson Creek and the South Fork Winchuck River are highly variable, ranging from a few hundred to more than 3,000 during the 1995-2000 period (see Appendix C-7 of the AHCP/CCAA).

Coastal cutthroat trout are now formally under the jurisdiction of the USFWS and are undergoing a status review. Cutthroat trout populations in southern Oregon and northern California are thought to be widely distributed in many small populations, with the exception of the Rogue and Smith Rivers, which support large and healthy populations (Johnson et al., 1999).

The Smith River is considered California's most important producer of coastal cutthroat trout. Cutthroat trout abundance trends in the Smith River increased 1 percent to 5 percent annually from 1982 to 1998 (Johnson et al., 1999). In addition, smolt abundance in Mill Creek (tributary to the Smith River) has increased during years 1994 though 1997 (Howard and Albro, 1997). Habitat in the Smith River estuary has been substantially degraded and cutthroat trout populations in the estuary are very low compared to historical estimates (Gerstung, 1997). Smolt counts in the Winchuck River from 1996 to 1998 show high variation, but the numbers trapped are encouraging, showing increases from 1,400 to 2,800 during this time period (Johnson et al., 1999). Cutthroat trout population estimates in the South Fork Winchuck have remained relatively stable at approximately 400 to 500 juveniles during the 1996 to 2000 period. No cutthroat were observed in Wilson Creek in 1997 and 1999 and estimates have ranged from less than 20 to approximately 160 in other years (see Appendix C-7 of the AHCP/CCAA).

Green Diamond conducted presence/absence surveys for tailed frogs in this HPA as part of a sampling of 72 streams throughout the entire Action Area to estimate the proportion of streams that supported populations of tailed frogs (Diller and Wallace 1999). In the Smith River Hydrographic Region, eight of eight (100 percent) streams sampled as part of presence/absence surveys had tailed frogs. In addition, populations of tailed frogs were confirmed in 27 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and the large number of streams known to support the species, tailed frogs streams in the Smith River Hydrographic Region appear to be in excellent condition.

Green Diamond conducted presence/absence surveys for southern torrent salamanders in this HPA as part of a sampling of 71 streams throughout the entire Action Area to estimate the proportion of streams that supported populations of southern torrent salamanders (Diller and Wallace 1996). In the Smith River HPA, seven of seven (100 percent) streams sampled as part of presence/absence surveys had torrent salamanders. In addition, populations of torrent salamanders were confirmed in 68 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and large number of streams known to support the species, southern torrent salamander streams in the Smith River Hydrographic Region appear to be in excellent condition.

3.4.4.2 Coastal Klamath Hydrographic Region

Channel and Estuary Conditions. Twenty-two creeks were examined within the Coastal Klamath Hydrographic Region, 6 by Green Diamond personnel and 16 by the Yurok Tribal Fisheries Program (YTFP) (see Appendix C-1 of the AHCP/CCAA). Canopy closure was relatively high (from 76 to 97 percent) in the 22 creeks assessed with the exception of Terwer and East Fork Terwer Creek, which were recovering from an extremely hot wildfire in 1988 and had canopy closure of 36 percent and 71 percent, respectively. The riparian canopy was primarily deciduous (from 73 percent to 97 percent) along all the creeks assessed. The percentage of LWD as the dominant structural shelter component in pools varied widely within the Coastal Klamath Hydrographic Region from a low of 6.8 percent in East Fork Terwer Creek to a high of 55.1 percent in East Fork Hunter Creek. The average value for the 22 creeks was 26.3 percent. Partitioning of habitat into pools, riffles, and runs showed a high percentage of riffles on Bear Creek (58 percent) and South Fork Ah Pah Creek (46 percent). Of the 22 assessed creeks, 17 had sections of dry channel, ranging from 1 to 86 percent of the total length surveyed. Mynot, Hunter, EF Hunter, Hoppaw, and Main Stem Ah Pah Creeks, all had over 24 percent of their total length in dry channel, and were the highest among the 22 creeks surveyed. Omagar Creek had 23 percent of the total length in culverts.

Fourteen of the 22 creeks assessed had high pool tailout embeddedness values (60 percent or more of pool tailouts reported as at least 50 percent embedded). Fourteen of the 22 creeks had predominantly (greater than 50 percent) shallow (less than 2 feet) pools.

Long-term channel monitoring is ongoing at four locations within the Coastal Klamath Hydrographic Region: two sites on Hunter Creek, and one site each on Hoppaw Creek and Tectah Creek. Monitoring began in 1996 on one site in Hunter Creek and in 1997 at the other three sites. No conclusions can be drawn at this point from the monitoring.

A LWD inventory was conducted during 1994 and 1995 in five streams within the Coastal Klamath Hydrographic Region: Hunter Creek, Terwer Creek, the North and South Forks of Ah Pah Creek, and Ah Pah Creek (see Appendix C-2 of the AHCP/CCAA). The mainstem and North and South Forks of Ah Pah Creek had some of the highest amounts of LWD of all the creeks surveyed in the Primary Assessment Area. Overall, there was a moderate level of both in-channel and recruitment zone LWD, but the size of the in-channel LWD was predominantly small (1 to 2 feet in diameter), reflecting the alder-dominant riparian zones prevalent throughout the Primary Assessment Area. The lack of large diameter LWD results in low levels of in-channel LWD available to function as shelter or to promote formation of pools. Stream health in the Coastal Klamath Hydrographic Region would benefit from increased abundance of large diameter and length LWD.

Like most northcoast watersheds, the Klamath River estuary has been impacted by human activities. The lower channel has lost some its wetland habitat to residential development. The estuary has been degraded by excessive sedimentation from the upper basin. The lower channel was also extensively cleared of snags and large woody debris at the turn of the century for commercial gillnetting and navigational purposes. Water diversions from the upper Klamath and Trinity Rivers affect the water quality of the estuary during summer months and probably contribute to the occasionally high water temperatures. Even with a large volume of flow, the Klamath River mouth periodically bars over and backfloods the lower river for several miles.

Species Status. Like the Smith River Hydrographic Region, the Coastal Klamath Hydrographic Region is in the SONCC ESU for Chinook, which NMFS has determined does not warrant listing (September 16, 1999, 64 FR 50394). Within this ESU, Chinook are well distributed in smaller coastal streams, and recent increases in abundance have been noted in these smaller coastal streams (September 16, 1999, 64 FR 50394). Chinook escapement in the Klamath Basin is greatly reduced from historic estimates and current escapement levels are dependent on hatchery production (Voight and Gale, 1998).

Coho populations are depressed throughout the SONCC ESU for coho salmon, which includes the Coastal Klamath Hydrographic Region. The SONCC coho salmon ESU has been listed as threatened under the ESA (May 6, 1997, 62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Coho runs in the Klamath Basin are greatly diminished from historical estimates and are largely hatchery supported today, although small wild runs exist in some tributaries (Weitkamp et al., 1995). Juvenile coho were present in 8 of 12 tributaries sampled by the YTFP within the Coastal Klamath Hydrographic Region in 1996, but were generally scarce and narrowly distributed within these tributaries (Voight and Gale, 1998). The ratio of wild fish to hatchery fish spawning naturally in these tributaries is unknown.

The Coastal Klamath Hydrographic Region is within the Klamath Mountains Province ESU for steelhead, which was determined to not warrant listing (April 4, 2001, 66 FR 17845). Specific information on steelhead in the Coastal Klamath Hydrographic Region is limited. YTFP sampling found juvenile steelhead to be well distributed in Coastal Klamath tributaries (100 percent presence, n=12 tributaries sampled), but no estimates of abundance were made (Voight and Gale, 1998). Steelhead populations in the Klamath River as a whole are significant, (summer/fall-run size of 110,000 fish, winter-run size of 20,000 fish) but believed to be largely hatchery supported (Busby et al., 1994).

Coastal cutthroat trout are now formally under the jurisdiction of the USFWS and are undergoing a status review. Short-term trends indicate increases in adult cutthroat trout abundance in the lower Klamath River and its tributaries (Johnson et al., 1999). The YTFP found juvenile coastal cutthroat trout to be well distributed and relatively abundant in Coastal Klamath Hydrographic Region tributaries (present in 10 of 12 tributaries sampled). However, the dominance and abundance of (presumably) resident cutthroat in areas above barriers to anadromy could mask declines in anadromous sea-run coastal cutthroat trout populations (Voight and Gale, 1998).

In the Coastal Klamath Hydrographic Region, 16 of 17 (94.1 percent) streams sampled as part of presence/absence surveys had tailed frogs (Diller and Wallace, 1999). In addition, populations of tailed frogs were confirmed in 26 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and large number of streams known to support the species, tailed frogs streams in the Coastal Klamath Hydrographic Region seem to be in excellent condition.

In the Coastal Klamath Hydrographic Region, 15 of 16 (93.8 percent) streams sampled as part of presence/absence surveys had torrent salamanders (Diller and Wallace, 1996). In addition, populations of torrent salamanders were confirmed in 81 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and large number of streams known to support the species, southern torrent salamander streams in the Coastal Klamath Hydrographic Region appear to be in excellent condition.

3.4.4.3 Blue Creek Hydrologic Unit

Channel and Estuary Conditions. Green Diamond has not conducted any channel and habitat typing assessment in the Blue Creek Hydrologic Unit. The YTFP has conducted channel and habitat typing on four streams in the Blue Creek Hydrologic Unit: mainstem Blue Creek, West Fork Blue Creek, Potato Patch Creek, and Slide Creek (see Appendix C-1 of the AHCP/CCAA). Canopy density was high on West Fork Blue Creek (87 percent) and Potato Patch Creek (95 percent), but low on main stem Blue Creek and Slide Creek (42 percent and 38 percent, respectively). The riparian canopy was predominantly deciduous, ranging from 66 to 91 percent in three of the four creeks. Riparian canopy was predominantly conifers on Slide Creek. LWD was a very small component of structural shelter in pools, with values varying from 1.5 to 6 percent in the surveyed creeks. Partitioning of habitat into pools, riffles, and runs showed a high (49 percent) percentage of riffles on West Fork Blue Creek and mainly flatwater and pools on the other three creeks.

Blue Creek and Slide Creek had low levels of pool tailout embeddedness, while more than 55 percent of pool tailouts in West Fork Blue and Potato Patch Creeks were at least 50 percent embedded. Blue Creek had predominantly deep pools (greater than 4 feet), while pools in the other three creeks were mostly less than 3 feet deep. No long-term channel monitoring have been conducted by Green Diamond in this HPA.

An LWD inventory was conducted during 1994 and 1995 in one stream within the Blue Creek Hydrologic Unit (see Appendix C-2 of the AHCP/CCAA). The number of instream LWD pieces per 100 feet of channel in West Fork Blue Creek (3.2) was somewhat greater than in other streams with similar watershed areas in the Primary Assessment Area.

Species Status. The Blue Creek Hydrologic Unit is in the SONCC ESU for Chinook salmon, which NMFS has determined does not warrant listing (September 16, 1999, 64 FR 50394). Blue Creek Chinook salmon populations have been monitored by the USFWS (1988 to 1992) and are currently monitored by the YTFP. Chinook escapement in the Klamath Basin is greatly reduced from historic estimates, but Blue Creek has a significant Chinook population that showed variable but overall increasing trends in both adult escapement and juvenile outmigrant abundance from 1988 to 1996. (Gale et al., 1998). Compared with other non-hatchery enhanced tributaries with similar drainage areas, Blue Creek Chinook are thought to be a significant component of the wild Chinook run in the Klamath Basin (Gale et al., 1998).

Coho populations are depressed throughout the SONCC ESU for coho salmon, which includes the Blue Creek Hydrologic Unit. The SONCC coho salmon ESU has been listed as threatened under the ESA (May 6, 1997, 62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. The Blue Creek Hydrologic Unit is somewhat unique in that it supports a significant population of native coho salmon with no evidence of hatchery produced fish in a river system otherwise characterized by heavy hatchery production and planting within many tributaries (Weitkamp et al., 1995, Gale et al., 1998). Estimates and trends in spawner escapements are hampered by low numbers of spawners and the difficulty in enumerating adult coho salmon, especially during high flow/poor visibility conditions. Qualitative snorkeling surveys indicate that portions of the Blue Creek Hydrologic Unit (especially the Crescent City Fork) have ideal spawning and rearing habitat for coho, and juvenile coho were observed utilizing this habitat in high densities (Gale et al., 1998).

The Blue Creek Hydrologic Unit is within the Klamath Mountains Province ESU for steelhead, which was determined to not warrant listing (April 4, 2001, 66 FR 17845). The Blue Creek Hydrologic Unit has ideal habitat for steelhead, and is thought to contain a large population of winter-run steelhead as well as a small number of summer-run steelhead. Snorkel surveys found juvenile steelhead to be abundant and well distributed throughout Blue Creek (Gale et al., 1998).

Coastal cutthroat trout are now formally under the jurisdiction of the USFWS and are undergoing a status review. Short-term trends indicate increases in adult cutthroat trout abundance in the lower Klamath River and its tributaries (Johnson et al., 1999). The YTFP reports that Blue Creek supports a small population of coastal cutthroat trout (Gale et al., 1998).

In the Blue Creek Hydrologic Unit, two of three (66.7 percent) streams sampled as part of presence/absence surveys had tailed frogs (Diller and Wallace, 1999). In addition, populations of tailed frogs were confirmed in seven other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. This HPA is very similar to the Coastal Klamath Hydrographic Region, which appears to have excellent habitat for tailed frogs.

In the Blue Creek Hydrologic Unit, four of four (100 percent) streams sampled as part of presence/absence surveys had torrent salamanders (Diller and Wallace, 1996). In addition, populations of torrent salamanders were confirmed in 32 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. This HPA is very similar to the Coastal Klamath Hydrographic Region, which appears to have excellent habitat for torrent salamanders.

3.4.4.4 Interior Klamath Hydrographic Region

Channel and Estuary Conditions. Green Diamond has not conducted any channel and habitat typing assessments in the Interior Klamath Hydrographic Region. The YTFP has conducted channel and habitat typing on 11 streams in the Interior Klamath Hydrographic Region: Johnson, Pecwan, East Fork Pecwan, Mettah, South Fork Mettah, Roach, a tributary to Roach, Morek, Cappel, Tully, and Robbers Creeks (see Appendix C-1 of the AHCP/CCAA). Canopy density ranged from 74 percent to 94 percent in the creeks surveyed. The riparian canopy was predominantly deciduous in all 11 creeks. Morek and Cappel Creeks had the greatest amount of conifer canopy (34 and 41 percent, respectively). The percent of LWD as a component of structural shelter in pools ranged from 1.7 percent in Pecwan Creek to 19.9 percent in South Fork Mettah Creek. The average value was 9.2 percent. Partitioning of habitat into pools, riffles, and flatwater showed that pools and flatwater comprised more than 70 percent of the total length in all ten creeks surveyed. Six streams had sections of dry channel, ranging from 1 percent in Robbers Creek to 13 percent in Johnson and Morek Creeks.

Ten of the streams assessed had high levels of pool tailout embeddedness (greater than 75 percent of pools at least 50 percent embedded). Tully Creek was the one exception. At least 50 percent of the pools in six creeks were greater than 2 feet deep, while Johnson, Mettah, South Fork Mettah, and the Roach Creek tributary Creeks exhibited mainly shallow pools (less than 2 feet deep). No long-term channel monitoring or LWD surveys have been conducted by Green Diamond in this HPA.

Species Status. The Interior Klamath Hydrographic Region is in the SONCC Chinook salmon ESU, which NMFS determined does not warrant listing as of September 1999 (64 FR 50394). Specific information on Chinook salmon in the Interior Klamath Hydrographic Region is limited. Chinook escapement in the Klamath Basin is greatly reduced from historic estimates and current escapement levels are dependent on hatchery production (Voight and Gale, 1998). Portions of this HPA also overlap with the Upper Klamath-Trinity Rivers ESU Chinook salmon, which NMFS has also determined does not warrant listing (63 FR 11482).

Coho salmon populations are depressed throughout the SONCC ESU, which includes the Interior Klamath Hydrographic Region. The SONCC coho salmon ESU has been listed as threatened under the ESA (May 6, 1997, 62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Specific information on coho salmon in the Interior Klamath Hydrographic Region is limited. Recent sampling (1996) by the YTFP observed low numbers of juvenile coho in two of three tributaries that have historically been reported to have coho (Voight and Gale, 1998).

The Interior Klamath Hydrographic Region is within the Klamath Mountains Province steelhead ESU for steelhead, which NMFS determined does not warrant listing as of April 4, 2001 (66 FR 17845). Attempts to assess the population status of steelhead in this ESU are hampered by a lack of biological information. In general, there has been a replacement of naturally produced fish with hatchery fish, and downward trends in abundance in most populations (Busby et al., 1994). Specific steelhead population abundance estimates for streams within the Interior Klamath Hydrographic Region are generally non-existent. YTFP sampling (1996) found juvenile steelhead are well-distributed in Interior Klamath tributaries (100 percent presence, n=4 tributaries sampled), but no estimates of abundance were made (Voight and Gale, 1998).

Coastal cutthroat trout are now formally under the jurisdiction of the USFWS and are undergoing a status review. Specific information on coastal cutthroat trout populations in the Interior Klamath Hydrographic Region is almost non-existent. The YTFP found coastal cutthroat in one of four Interior Klamath Hydrographic Region tributaries surveyed in 1996 (Gale et al., 1998). Gerstung (1997) suggests that coastal cutthroat trout typically do not occur above Mettah Creek.

In the Interior Klamath Hydrographic Region, seven of 11 (63.6 percent) streams sampled as part of presence/absence surveys had tailed frogs (Diller and Wallace, 1999). In addition, populations of tailed frogs were confirmed in five other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this moderate rate of occurrence and relatively small number of streams known to support the species, tailed frogs streams in the Interior Klamath Hydrographic Region appear to be in moderate condition.

In the Interior Klamath Hydrographic Region, 10 of 11 (90.9 percent) streams sampled as part of presence/absence surveys had torrent salamanders (Diller and Wallace, 1996). In addition, populations of torrent salamanders were confirmed in 56 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and large number of streams known to support the species, southern torrent salamander streams in the Interior Klamath Hydrographic Region appear to be in excellent condition.

3.4.4.5 Redwood Creek Hydrologic Unit

Channel and Estuary Conditions. No channel or habitat typing assessments, long-term channel monitoring or LWD surveys have been conducted by Green Diamond in this HPA. After the flood of 1964, which inundated the town of Orick with five feet of water, the U.S. Army Corps of Engineers (Corps) constructed a levee from Prairie Creek to the ocean. During low summer flows, the north and south sloughs of the estuary become isolated and anoxic. The lower three miles of Redwood Creek also are devoid of riparian vegetation and LWD because the Corps requires that the levee’s channel be clear of debris, that may lessen its transport capacity.

Species Status. The Redwood Creek Hydrologic Unit is the northernmost boundary of the California Coastal ESU for Chinook salmon, which was listed as threatened under the ESA on September 16, 1999 (64 FR 50394). Low abundance levels, sporadic occurrence in some river systems, and negative long term trends in abundance were cited in the decision to list the California Coastal Chinook salmon ESU as threatened (September 16, 1999, 64 FR 50394). Specific information on Chinook in the Redwood Creek Hydrologic Unit is limited. Nehlsen et al. (1991) characterized fall-run Chinook in Redwood Creek as at “moderate risk of extinction,” and a reanalysis by Higgins et al. (1992) resulted in an upgrade in status to “stocks of special concern.”

Coho salmon populations are depressed throughout the SONCC ESU, which includes the Redwood Creek Hydrologic Unit. Current coho salmon abundance in the California portion of this ESU is thought to be less than 6 percent of their abundance in the 1940s (Weitkamp et al., 1995). The SONCC coho ESU has been listed as threatened under the ESA as of May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005.

The Redwood Creek Hydrologic Unit is the northern boundary of the Northern California DPS for steelhead, which was listed as threatened on January 5, 2006 (71 FR 834). Steelhead abundance data is very limited for this DPS, but available data indicates that winter-run steelhead populations declined significantly prior to 1970, and populations have remained at depressed levels with no clear trends since then. Nehlsen et al. (1991) identified summer steelhead in Redwood Creek as “at risk of extinction.” NMFS found that for the populations of steelhead within this DPS only the small summer steelhead population within the Mad River, which has had large supplemental production from hatchery sources, and Prairie Creek winter steelhead have shown recent trends of increasing abundance (June 7, 2001, 65 FR 36074). Prairie Creek is a tributary to Redwood Creek and as such is within the Redwood Creek Hydrologic Unit.

Redwood Creek historically supported a large population of anadromous coastal cutthroat trout. The current population is thought to be very depressed compared to historical estimates, but relatively stable (Gerstung, 1997). Severe alteration of the estuary environment and habitat degradation from logging in the 1950s and 1960s, compounded by the 1964 flood, are believed to be largely responsible for the depressed cutthroat trout population in Redwood Creek (Gerstung, 1997). This species is now under the jurisdiction of the USFWS and is undergoing a status review.

In the Redwood Creek Hydrologic Unit, six of six (100 percent) streams sampled as part of presence/absence surveys had tailed frogs (Diller and Wallace, 1999). In addition, populations of tailed frogs were confirmed in 11 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. The high rate of occurrence and significant number of other streams known to support the species suggest that tailed frogs streams in the Redwood Hydrologic Unit are in good condition.

In the Redwood Creek Hydrologic Unit, five of six (83.3 percent) streams sampled as part of presence/absence surveys had torrent salamanders (Diller and Wallace, 1996). In addition, populations of torrent salamanders were confirmed in 61 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. The high rate of occurrence and large number of other streams known to support the species suggest that torrent salamander streams in the Redwood Creek Hydrologic Unit are in good condition.

3.4.4.6 Coastal Lagoons Hydrographic Region

Channel and Estuary Conditions. No channel or habitat typing assessments or LWD surveys have been conducted by Green Diamond in this HPA. Long-term channel monitoring is ongoing in two locations within the Coastal Lagoons Hydrographic Region - Maple Creek and Beach Creek. Monitoring began on both reaches in 1998. No conclusions can be drawn at this point from the monitoring.

Stone Lagoon is approximately 500 acres in size and is where salmonids from McDonald Creek generally rear to maturity. Because the lagoon only opens to the ocean occasionally, salmonids have limited opportunities to pass between the two water bodies. However, the brackish lagoon is highly productive and supports a diverse aquatic ecosystem.

Species Status. Specific information on anadromous salmonids in the Coastal Lagoons Hydrographic Region is limited. Population sizes are probably small and potentially non-existent in some years, as Big and Stone Lagoons are only open to the ocean for short time periods in winter and early spring, limiting the ability of anadromous fishes to migrate between the ocean and the lagoons.

The Coastal Lagoons Hydrographic Region is within the California Coastal Chinook salmon ESU, which was listed as threatened under the Federal ESA as of September 16, 1999 (64 FR 50394). This HPA is within the SONCC coho salmon ESU, which was listed as threatened on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. The Coastal Lagoons Hydrographic Region is within the Northern California steelhead DPS, which was listed as threatened on January 5, 2006 (71 FR 834). Coastal cutthroat are now under the jurisdiction of the USFWS and are undergoing a status review.

As many as 1,200 coho salmon and 3,000 steelhead may have occurred in Maple Creek, a tributary to Big Lagoon, as late as the 1960s (USFWS, 1967). Recent spawning surveys conducted by Green Diamond personnel during 1998 and 1999 have observed only a small number of redds, indicating limited spawning by salmonids in Maple, North Fork Maple, and Pitcher Creeks (see Appendix C-9 of the AHCP/CCAA). Big Lagoon is believed to support a “fair” population of coastal cutthroat trout (Gerstung, 1997). Green Diamond fisheries personnel observed high numbers of large coastal cutthroat in lower Maple Creek in 1999. Stone Lagoon had low numbers of cutthroat prior to heavy stocking of yearling fish in 1990 through 1994. Spawning escapement in McDonald Creek increased dramatically in the years following the stocking, but conditions in McDonald Creek are degraded and limit natural production (Gerstung, 1997).

Properties in the Coastal Lagoons Hydrographic Region were acquired by Green Diamond in 1998 after presence/absence surveys for tailed frogs had been completed. As a result, there is no estimate of the proportion of streams that support tailed frogs in this HPA. However, populations of tailed frogs have been confirmed in 22 streams throughout the HPA, either through other types of amphibian surveys by the prior landowner or incidental observations since the acquisition of the property by Green Diamond. Given the significant number of streams known to support the species, tailed frogs streams in the Coastal Lagoon Hydrographic Region are likely to be in good condition.

Populations of torrent salamanders have been confirmed in 47 streams throughout the HPA, either through other types of amphibian surveys by the prior landowner or incidental observations since the acquisition of the property by Green Diamond. Given the significant number of streams known to support the species, torrent salamander streams in the Coastal Lagoon Hydrographic Region are likely to be in good condition.

3.4.4.7 Little River Hydrologic Unit

Channel and Estuary Conditions. Channel and habitat typing assessments in the Little River Hydrologic Unit were conducted by Louisiana-Pacific Corporation fisheries personnel in 1994. Four streams were surveyed: the mainstem Little River, Upper and Lower South Fork Little River, and Railroad Creek (see Appendix C-1 of the AHCP/CCAA). Canopy density in the Little River Hydrologic Unit was high, ranging from 91 percent to 99 percent in the three streams surveyed. The species composition of the riparian canopy was predominantly deciduous on all streams. LWD was the dominant structural shelter component in pools and ranged from 17.3 percent to 38.5 percent. Partitioning of habitat into pools, riffles, and runs showed a high percentage of pools (45 percent to 56 percent) on all four streams surveyed.

Pool tailout embeddedness values were moderate, mainly in the 26 percent to 50 percent range. Pool depths were predominantly 3 feet or less on Railroad Creek and the South Fork Little River, while half of the mainstem Little River pool depths were greater than 3 feet. No long-term channel monitoring has been conducted by Green Diamond in this HPA.

An LWD inventory was conducted during 1994 and 1995 in the same four streams in which channel and habitat type assessments were conducted. The instream LWD piece counts per 100 feet of channel were relatively high for the watershed size in Railroad Creek, and the Upper and Lower South Fork Little River, ranging from 5.1 to 8.1 pieces per 100 feet. LWD in the mainstem Little River was also more numerous than other streams in the Primary Assessment Area with similar watershed sizes (see Appendix C-2 of the AHCP/CCAA).

The Little River estuary has been impacted to a certain degree by human activities. Livestock grazing has denuded some of the riparian zone along the lower channel, accelerating the erosion of streambanks. In spite of this, the Little River has more estuarine habitat than many local streams of its size, and surveys have indicated utilization of the estuary by juvenile Chinook salmon (LP, 1986, CDFG, 1986). Although the Little River watershed is relatively small, its mouth rarely, if ever, bars over during the summer to form an enclosed lagoon.

Species Status. The Little River Chinook population is depressed compared to historical estimates, but recent trends show a relatively stable population. Green Diamond personnel have observed small numbers of live adult and carcasses of spawned out Chinook salmon, as well as redds, during spawning surveys conducted within the Little River during 1998 through 2000. Other tributaries to Little River (Upper South Fork and Lower South Fork Little River) had lower numbers of spawning Chinook salmon observed during those surveys The Little River is considered one of the best local salmonid streams, with healthy genetic stocks, sufficient returns to seed the system, and good salmonid habitat (Weseloh and Farro, pers. comm.). The Little River Hydrologic Unit is within the California Coastal Chinook salmon ESU, which was listed as threatened under the Federal ESA as of September 16, 1999 (64 FR 50394).

The Little River coho population is depressed compared to historical estimates, but appears to be relatively stable over the last decade. Recent data indicates high numbers and densities of juvenile coho from the 1998-1999 brood year. Spawning surveys conducted by Green Diamond personnel have resulted in observations of live adults, and carcasses of spawned-out coho salmon, as well as coho redds, within Little River during 1998 through 2000, and the lower South Fork Little River from 1998 to 1999 (see Appendix C-9 of the AHCP/CCAA). Coho salmon dominated the out-migrant smolt estimates in the Lower South Fork Little River and Carson Creek in 2000, exceeding 1,600 and 1,800 smolts respectively (see Appendix C-8 of the AHCP/CCAA). As noted previously, the Little River is considered one of the best local salmonid streams, with healthy genetic stocks, sufficient returns to seed the system, and good salmonid habitat. This HPA is within the SONCC coho salmon ESU, which was listed as threatened on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005.

The Little River Hydrologic Unit is within the Northern California DPS for steelhead, which was listed as threatened on January 5, 2006 (71 FR 834). Steelhead abundance data are limited for this DPS, but available data indicate that winter-run populations declined significantly prior to 1970, and populations have remained at depressed levels with no clear trends since then (Busby et al., 1996). Specific information on steelhead populations in the Little River Hydrologic Unit indicates that the Little River has been and remains an excellent system for steelhead production, although current abundance is depressed compared to historical estimates. Outmigrant trapping in 1994 captured approximately 10,000 steelhead parr and 1,100 smolts (Shaw and Jackson, 1994). The ability of steelhead to use spawning and rearing habitat upstream of other salmonids in the Little River contributes to their success in this HPA (Weseloh and Farro, pers. comm.).

Coastal cutthroat trout are now under the jurisdiction of the USFWS and are undergoing a status review. Cutthroat trout populations in southern Oregon and northern California are thought to be widely distributed in many small populations, with the exception of the Rogue and Smith Rivers, which support large and healthy populations (Johnson et al., 1999). Specific information on coastal cutthroat trout populations in the Little River Hydrologic Unit are limited to recent estimates and observations; historical information for comparison is lacking. Outmigrant trapping in the mainstem Little River in 1994 captured 403 coastal cutthroat trout, ranging in size from 50 to 275 mm, with the bulk around 150 mm (Shaw and Jackson, 1994).

Properties in the Little River Hydrologic Unit were acquired by Green Diamond in 1998 after presence/absence surveys for tailed frogs had been completed. As a result, there is no estimate of the proportion of streams that support tailed frogs in this HPA. However, populations of tailed frogs have been confirmed in 15 streams throughout the HPA, either through other types of amphibian surveys by the prior landowner or incidental observations since the acquisition of the property by Green Diamond. Given the significant number of streams known to support the species, tailed frogs streams in the Little River Hydrologic Unit are likely to be in good condition.

Populations of torrent salamanders have been confirmed in 18 streams throughout the HPA, either through other types of amphibian surveys by the prior landowner or incidental observations since the acquisition of the property by Green Diamond. Given the significant number of streams known to support the species, torrent salamanders streams in the Little River Hydrologic Unit are likely to be in good condition.

3.4.4.8 Mad River Hydrographic Region

Channel and Estuary Conditions. Channel and habitat typing assessment was conducted in 1994/1995 in three streams in the Mad River Hydrographic Region: Lindsay Creek, Dry Creek, and Cañon Creek (see Appendix C-1 of the AHCP/CCAA). Lindsay Creek and Cañon Creek had average canopy closures of approximately 80 percent, while Dry Creek had a canopy closure of 92 percent. This canopy was composed of 75 percent to 85 percent deciduous trees. The percentage of LWD as shelter in pools ranged from 14 percent in Dry Creek to 27 percent in Lindsay Creek. Partitioning of habitat into pools, riffles, and runs showed a high (47 percent and 50 percent, respectively) percentage of pools in both Lindsay and Cañon Creeks, a feature indicative of good salmonid habitat. Dry Creek was predominantly (67 percent) riffles.

Pool tailout embeddedness was moderate in Cañon Creek and Dry Creek and high in Lindsay Creek, with 82 percent of the pools having embeddedness values of 50 percent or greater. Pool depths in Dry Creek were almost all less than 2 feet, while Canon and Lindsay Creek pool depths were predominantly between 2 and 4 feet, with 17.6 and 15.6 percent of pools greater than 4 feet deep in Cañon Creek and Lindsay Creek, respectively.

Long-term channel monitoring is ongoing in one location within the Mad River Hydrographic Region. Monitoring began on the Cañon Creek in 1995. No conclusions can be drawn at this point from the monitoring.

There was a low level of both in-channel and recruitment zone LWD in Dry Creek and Cañon Creek, and a moderate level of LWD in Lindsay Creek (see Appendix C-2 of the AHCP/CCAA). The size of the inchannel LWD was predominantly small (less than 2 foot diameter), reflecting the alder-dominant riparian zones prevalent throughout the Primary Assessment Area. The LWD survey results may be misleading for Lindsay Creek, where most of the LWD is keyed into the banks, so that it is measured as small diameter and length, yet it affords the shelter and pool forming advantage of larger LWD. In Cañon Creek and Dry Creek, the lack of large diameter LWD results in low levels of in-channel LWD available to function as shelter or to promote formation of pools. Stream health in the Mad River Hydrographic Region would benefit from increased abundance of large diameter and length LWD.

The Mad River estuary has been severely impacted by human settlement, beginning with the draining and diking of wetlands for agricultural use. The Arcata Bottoms (once the Mad River floodplain) has been extensively developed for livestock grazing and residential purposes. In addition, to prevent regular flooding of this area, a meander in the lower Mad River was cut off by excavation of a new channel segment in 1862. The lower channel was cleared of LWD jams to facilitate the transport of logs in the late 1800s. Since then, the unrestricted removal of logs by firewood cutters in the lower reaches has inhibited re-establishment of LWD in this area. Gravel extraction occurs at numerous locations below the Mad River Hatchery and has been an important commercial activity for some time, removing approximately 15.5 million cubic yards of gravel between 1952 and 1992. The Humboldt Bay Municipal Water District, which provides water to communities and industry around Humboldt Bay, pumps its water from wells in the lower Mad River, just above the Highway 299 Bridge. This history of development has resulted in channelization of the lower 10 miles of the Mad River.

Species Status. The Mad River Hydrographic Region is within the California Coastal Chinook salmon ESU, which was listed as threatened under the ESA as of September 16, 1999 (64 FR 50394). Low abundance levels, sporadic occurrence in some river systems, and negative long term trends in abundance in this ESU were cited in the decision to list this ESU as threatened (September 16, 1999, 64 FR 50394). Nehlsen et al. (1991) identified Mad River fall-run Chinook as at moderate risk of extinction. Abundance trends have declined in the Mad River Basin over the long term, but show signs of increasing in recent years (64 FR 50405). Spawning surveys have been conducted annually on Canon Creek from 1995 through 2000. Compared to other species, large numbers of Chinook adults, redds, and carcasses have been observed during all years surveyed (see Appendix C-9 of the AHCP/CCAA).

Mad River Hatchery coho salmon stocks are not considered part of the SONCC coho salmon ESU, as they have included transplants from outside the area (Weitkamp et al., 1995). Coho salmon in the Mad River Hydrographic Region are within the SONCC coho salmon ESU, which was listed as threatened on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Coho salmon are fairly well-distributed within the lower portion of this HPA, but almost no information on total abundance or proportion of naturally spawning hatchery fish is available. Spawning surveys have been conducted annually on Canon Creek from 1995 through 2000. Very few coho adults, redds, and carcasses have been observed in any year (see Appendix C-9 of the AHCP/CCAA). Juvenile summer population estimates for coho salmon ranged from 43 to 919 juveniles during the 1995-2000 period (see Appendix C-7 of the AHCP/CCAA).

Summer steelhead abundance in the Mad River has been monitored from 1982 to the present, revealing unexpectedly high abundance in 1994 through 1996, with a sharp downward trend in more recent years (see Appendix C-10 of the AHCP/CCAA). Information on fall-run and winter-run steelhead is lacking. The genetic effects of the Mad River Hatchery steelhead releases on the native winter steelhead population is a source of concern in this HPA (Busby et al., 1996). However, the hatchery program was terminated in 2004 so that potential genetic risks associated with propagation of this non-DPS stock will decline in the future. The Mad River Hydrographic Region is within the Northern California steelhead DPS, which was listed as threatened on January 5, 2006 (71 FR 834).

Cutthroat trout are only occasionally observed in the lower main stem Mad River, but are abundant in some lower Mad River tributaries, including Lindsay, Widow White, and Mill Creeks (Gerstung, 1997). Coastal cutthroat trout have not been observed above the confluence North Fork Mad River. This species is now under the jurisdiction of the USFWS and is undergoing a status review.

In the Mad River Hydrographic Region, 7 of 12 (58.3 percent) streams sampled as part of presence/absence surveys had tailed frogs, primarily in the lower portion of the drainage (Diller and Wallace, 1999). In addition, populations of tailed frogs were confirmed in 17 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations, only one observation was in the upper portion of the HPA. Given this moderate rate of occurrence and somewhat limited number of streams known to support the species, tailed frog streams in the Mad River Hydrographic Region appear to be in moderate condition. However, other tailed frog studies (e.g., headwaters monitoring and life history studies) in this HPA indicate that, depending on the localized geology, some streams provide excellent habitat for tailed frogs while others completely lack habitat for the species.

In the Mad River Hydrographic Region, 8 of 12 (66.7 percent) streams sampled as part of presence/absence survey had torrent salamanders (Diller and Wallace, 1996). In addition, populations of torrent salamanders were confirmed in 54 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given the moderate rate of occurrence, torrent salamander streams in the lower portion of the Mad River Hydrographic Region appear to be in relatively poor condition. However, other torrent salamander studies (e.g., headwaters monitoring and life history studies) and the relatively large number of streams known to support the species in this HPA indicate that, depending on the localized geology, some streams provide excellent habitat for torrent salamanders while others completely lack habitat for the species.

3.4.4.9 North Fork Mad River Hydrologic Unit

Channel and Estuary Conditions. Channel and habitat typing assessments were performed on two creeks within the North Fork Mad River Hydrologic Unit: North Fork Mad River and Long Prairie Creek (see Appendix C-1 of the AHCP/CCAA). Canopy density was 73 percent on the North Fork Mad River and 95 percent on Long Prairie Creek. Deciduous trees accounted for about 90 percent of the canopy on both creeks. LWD as structural shelter in pools was low in both creeks – 12.1 percent and 10.4 percent in the North Fork and Long Prairie Creek, respectively. Partitioning of habitat into pools, riffles, and runs showed a high percentage (47 percent) of riffles on Long Prairie Creek, and a high percentage (42 percent) of pools on the North Fork Mad River. The North Fork had 10 percent of its total length in dry channel.

Pool tailout embeddedness was high on the North Fork and low on Long Prairie Creek. Pool depths showed the opposite pattern. In the North Fork, over 50 percent of the pools were greater than 3 feet deep, while in Long Prairie Creek, less than 16 percent of the pools were greater than 3 feet deep. The differences in pool depth undoubtedly reflect the much larger size of the North Fork Mad River.

Long-term channel monitoring is ongoing at one location within the North Fork Mad River Hydrologic Unit. Monitoring began on the North Fork Mad River in 1997. An abbreviated version of the complete monitoring protocol is being used. No conclusions can be drawn at this point from the monitoring.

The North Fork Mad River had approximately one piece of in-channel LWD per 100 feet of channel, while Long Prairie Creek averaged 2.2 pieces per 100 feet. The size of the in-channel LWD present was predominantly small (less than 2 feet diameter), reflecting the alder-dominant riparian zones prevalent throughout the area (see Appendix C-2 of the AHCP/CCAA). The lack of large diameter LWD results in low levels of in-channel LWD available to function as shelter or to promote formation of pools. Stream health in the North Fork Mad River Hydrologic Unit would benefit from increased abundance of large diameter and length LWD.

Species Status. Nehlsen et al. (1991) identified Mad River fall-run Chinook salmon as at moderate risk of extinction. The North Fork Mad River Hydrologic Unit is within the California Coastal Chinook salmon ESU, which was listed as threatened under the ESA as of September 16, 1999 (64 FR 50394). Abundance trends have declined in the Mad River Basin as a whole over the long term, but show signs of increasing in recent years (September 16, 1999, 64 FR 50394). A natural barrier to Chinook and coho salmon migration occurs at roughly river mile (RM) 4 in the North Fork Mad River, severely limiting the spawning and rearing area available to Chinook in this HPA. Spawner surveys in this HPA indicate highly variable returns of winter-run Chinook to the North Fork Mad River and its tributaries below the barrier.

The North Fork Mad River Hydrologic Unit is within the SONCC coho salmon ESU, which was listed as threatened on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Spawner surveys and juvenile population estimates below the barrier also indicate low numbers of coho returns in this HPA (see Appendices C-7 and C-9 of the AHCP/CCAA).

Steelhead are able to pass the natural barrier mentioned previously for Chinook and coho salmon and therefore can use more of the North Fork drainage than other anadromous salmonids. The genetic effects of the Mad River Hatchery steelhead releases on the native winter steelhead population are a source of concern in the Mad River Basin (Busby et al., 1996). However, the hatchery program was terminated in 2004 so that potential genetic risks associated with propagation of this non-DPS stock will decline in the future. The extent of hatchery fish spawning naturally in the North Fork Mad River HPA is unknown. The North Fork Mad River Hydrographic Unit is within the Northern California steelhead DPS, which was listed as threatened on January 5, 2006 (71 FR 834).

Coastal cutthroat are now under the jurisdiction of the USFWS and are undergoing a status review. Little is known about coastal cutthroat trout in the North Fork Mad River Hydrologic Unit. The natural barrier to anadromy on the main stem North Fork Mad implies that cutthroat trout in most of this HPA (above the barrier) are resident fish.

In the North Fork Mad River Hydrologic Unit, six of seven (85.7 percent) streams sampled as part of presence/absence surveys had tailed frogs (Diller and Wallace, 1999). In addition, populations of tailed frogs were confirmed in 28 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and the large number of streams known to support the species, tailed frogs streams in the North Fork Mad River Hydrologic Unit seem to be in excellent condition.

In the North Fork Mad River Hydrologic Unit, six of seven (85.7 percent) streams sampled as part of presence/absence surveys had torrent salamanders (Diller and Wallace, 1996). In addition, populations of torrent salamanders were confirmed in 80 other streams throughout the HPA, either through other types of amphibian surveys or incidental observations. Given this high rate of occurrence and large number of streams known to support the species, torrent salamanders streams in the North Fork Mad River Hydrologic Unit seem to be in excellent condition.

3.4.4.10 Humboldt Bay Hydrographic Region

Channel and Estuary Conditions. Channel and habitat typing assessments were conducted on four streams within the Humboldt Bay Hydrographic Region in 1995. Salmon Creek was assessed by Green Diamond personnel and Ryan Creek and two unnamed tributaries to Ryan Creek were assessed by the California Conservation Corps (see Appendix C-1 of the AHCP/CCAA). Canopy closure was high on all four creeks, ranging from 88 percent in Salmon Creek to 94 percent in Ryan Creek. The riparian canopy was predominantly deciduous on Salmon Creek and Ryan Creek (83 and 68 percent). This variable was not recorded on the two tributaries to Ryan Creek. The percentage of LWD as shelter in pools was 27.5 percent in Salmon Creek, and 17, 40, and 49 percent, respectively, in the two tributaries to Ryan Creek and the Ryan Creek mainstem. These are some of the higher values in Primary Assessment Area streams.

Partitioning of habitat into pools, riffles, and runs showed a moderately high percentage (44 percent) of pools on Salmon Creek and a high percentage of pools on Ryan Creek and the two assessed tributaries (65, 81, and 61 percent, respectively).

Pool tailout embeddedness was very high in all four creeks, probably because of the dominant substrate materials in these creeks. Pool depths were mainly 1 to 3 feet, with

18 percent greater than 4 feet in Salmon Creek. The assessed creeks in the Humboldt Bay Hydrographic Region had a high level of canopy closure and LWD as shelter, but very fine substrate was predominant, leading to high embeddedness values, shallow pools, and low overall shelter ratings. Long-term channel monitoring is ongoing in one location within the Humboldt Bay Hydrographic Region. Monitoring began on Salmon Creek in 1996. No conclusions can be drawn at this point from the monitoring.

Generalizations about LWD in the Humboldt Bay Hydrographic Region are difficult to make as only one creek in the region was surveyed (see Appendix C-2 of the AHCP/CCAA). Salmon Creek had an average of 4.0 pieces of in-channel LWD per 100 feet, one of the highest densities among the streams surveyed. The size of the in-channel LWD was predominantly small (less than 2 ft diameter), reflecting the alder-dominant riparian zones prevalent throughout the area. The lack of large diameter LWD results in low levels of in-channel LWD available to function as shelter or to promote the formation of pools. Stream health in the Humboldt Bay Hydrographic Region would benefit from increased abundance of large diameter and length LWD.

The estuaries of Humboldt Bay's watersheds have been vastly altered over the past century. Residential and agricultural development associated with the early harvesting of timber from the slopes surrounding Humboldt Bay greatly impacted watershed estuaries. Extensive areas of highly productive wetlands were converted to pasture and residential land through a complex series of dikes, tide gates, and levees. The lower section of Salmon Creek was channelized to maximize the amount of available pasture land. The tide gate on Salmon Creek has been suspected as being impassable by adult and juvenile salmonids on a wide range of flows. Recently, a section of the lower channel (now a National Wildlife Refuge) was reconstructed to its natural meander and the tide gate was modified to improve fish passage.

Species Status. The Humboldt Bay Hydrographic Region is within the California Coastal Chinook salmon ESU, which was listed as threatened under the ESA as of September 16, 1999 (64 FR 50394). Drainages within the Humboldt Bay Hydrographic Region are typically small, with no large rivers, which are typically preferred by Chinook salmon. Chinook populations within this HPA are thought to be low, and while historical estimates are not available for comparison, the small size of the Humboldt Bay drainages makes it unlikely that this HPA was ever a significant producer of Chinook salmon.

The Humboldt Bay Hydrographic Region is within the SONCC coho salmon ESU, which was listed as threatened on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Coho salmon have been documented in almost all of the drainages feeding Humboldt Bay. Information on coho abundance in these creeks is limited, but as with the ESU as a whole, current numbers are almost certainly depressed relative to historical estimates (Weitkamp et al., 1995).

The Humboldt Bay Hydrographic Region is within the Northern California DPS for steelhead, which was listed as threatened on January 5, 2006 (71 FR 834). Steelhead abundance data are limited for this ESU, but available data indicate that winter-run populations declined significantly prior to 1970, and populations have remained at depressed levels with no clear trends since then (Busby et al., 1996).

Coastal cutthroat trout are now under the jurisdiction of the USFWS and are undergoing a status review. Gerstung (1997) reports that low numbers of coastal cutthroat have been reported in most tributaries where other salmonids are present, while much higher numbers have been observed in tributaries or headwaters of tributaries where no other salmonids are present. Current populations are thought to be depressed relative to historic levels (Gerstung, 1997).

In the Humboldt Bay Hydrographic Region, only two streams were sampled as part of presence/absence surveys and tailed frogs were found in one of them (Diller and Wallace, 1999). In addition, tailed frogs have only been found in 3 other streams throughout the HPA as the result of incidental observations. However, much of this HPA is located within young unconsolidated geologic formations, which have been shown to have a strong negative influence on tailed frog occurrence as a result of a lack of suitable stream substrate in these geologic formations (Diller and Wallace, 1999). Most streams in the Humboldt Bay Hydrographic Region are likely not suitable for tailed frogs and have no potential to become suitable outside of a geologic timeframe.

In the Humboldt Bay Hydrographic Region, only three streams were sampled as part of presence/absence surveys and no torrent salamanders were found in any of them (Diller and Wallace, 1996). In addition, torrent salamanders have only been found in three other streams throughout the HPA as the result of incidental observations. However, as noted above for tailed frogs, much of this HPA is located within young unconsolidated geologic formations. These formations have been shown to have a strong negative influence on torrent salamander occurrence due to a lack of suitable stream substrate in these geologic formations (Diller and Wallace, 1996).

3.4.4.11 Eel River Hydrographic Region

Channel and Estuary Conditions. Channel and habitat typing assessments have not been conducted by Green Diamond personnel within the Eel River Hydrographic Region. The CDFG has conducted channel and habitat typing assessments on four streams within the Eel River Hydrographic Region. Wilson Creek and Stevens Creek were both assessed in 1991, and Howe Creek and West Fork Howe Creek were assessed in 1998 (see Appendix C-1 of the AHCP/CCAA).

Canopy closure was moderate in the four creeks surveyed, ranging from 57 percent in Howe Creek to 86 percent in West Fork Howe Creek. The existing canopy was mainly deciduous in all four creeks (71 to 95 percent deciduous). The percentage of LWD as the dominant structural shelter component in pools varied widely within the Eel River Hydrographic Region from zero percent in West Fork Howe Creek to a high of 48 percent in Stevens Creek. The average value for the four creeks was 15.5 percent.

Partitioning the streams into pools, riffles, and runs showed a high percentage of riffles on Wilson Creek (86 percent), Howe Creek (65 percent), and West Fork Howe Creek (74 percent). Only Stevens Creek had more than 10 percent of its total length composed of pool habitat (26 percent pools).

Howe, West Fork Howe, and Wilson Creeks all had high pool tailout embeddedness values as well as mainly shallow (less than 2 feet) pools. Stevens Creek had low pool tailout embeddedness and 57 percent of its pools were greater than 2 feet in depth. Stevens Creek contains significantly better salmonid habitat than the other three creeks assessed in the Eel River Hydrographic Region.

Green Diamond has not conducted any LWD inventories within the Eel River Hydrographic Region, and no long-term channel monitoring reaches have been established in the Eel River Hydrographic Region.

The lower Eel River has lost valuable fisheries habitat through human activities. Wetlands, secondary channels, and sloughs have been impacted through extensive diking and channelization. The original floodplain is now used for residential and agricultural purposes, mainly grazing of dairy cattle. Sediment deposits transported from upstream areas have turned once deep pools into shallow runs, which offer marginal habitat for juvenile salmonids. The lower channel was also cleared of LWD jams for navigational purposes.

Species Status. Peak index counts and carcass surveys for Chinook salmon in two tributaries to the Eel River have shown precipitous long-term declines since the 1960s, with recent increases in one tributary. Similar monitoring for Chinook salmon in other tributaries conducted since the late 1980s have also shown steep declines. Spring-run Chinook salmon in the upper Eel River are possibly extinct, representing a significant loss of life history diversity in this ESU as a whole (64 FR 50405). The Eel River Hydrographic Region is within the California Coastal Chinook salmon ESU, which was listed as threatened under the ESA as of September 16, 1999 (64 FR 50394).

The Eel River Hydrographic Region is within the SONCC coho salmon ESU which was listed as threatened on May 6, 1997 (62 FR 24588). Coho salmon north of Punta Gorda were listed as threatened under CESA on March 30, 2005. Coho salmon abundance in the Eel River, as within the rest of the SONCC coho ESU, is depressed (Weitkamp et al., 1995). The abundance of introduced Sacramento pike minnow in the Eel River is a cause for concern.

Nehlsen et al. (1991) identified summer steelhead in the Eel River as at risk of extinction, although the Little Van Duzen River winter steelhead stock was identified as stable in further analysis by Higgins et al. (1992). Counts at Eel River dams in the 1930s and 1940s averaged 4,400 adult steelhead annually at Cape Horn Dam and 19,000 adult steelhead annually at the Benbow Dam. Recent counts at Cape Horn Dam average 115 adults, of which only 30 are native fish. In addition to these declining trends, the abundance of the introduced Sacramento pike minnow and sedimentation are some of the main concerns cited for steelhead in the Eel River (Busby et al., 1996). The Eel River Hydrographic Region is within the Northern California DPS for steelhead, which was listed as threatened on January 5, 2006 (71 FR 834).

Coastal cutthroat trout are now under the jurisdiction of the USFWS and are undergoing a status review. Cutthroat trout are found in one tributary to the lower Eel (Strongs Creek), one tributary to the Van Duzen (Fox Creek), and a few small streams which flow into the Salt River Slough (Gerstung, 1997). No Primary Assessment Area lands exist in the drainages of these tributaries.

In the Eel River Hydrographic Region, only two streams were sampled as part of presence/absence surveys and no tailed frogs were found in either of them (Diller and Wallace, 1999). In addition, no tailed frogs have been found in other streams throughout the

HPA as the result of incidental observations. However, much of this HPA is located within young unconsolidated geologic formations, which have been shown to have a strong negative influence on tailed frog occurrence due to a lack of suitable stream substrate in these geologic formations (Diller and Wallace, 1999). Most streams in the Eel River Hydrographic Region are likely not suitable for tailed frogs and have no potential to become suitable outside a geologic timeframe.

In the Eel River Hydrographic Region, only one stream was sampled as part of presence/absence surveys and no torrent salamanders were found (Diller and Wallace, 1996). In addition, no torrent salamanders have been found in other streams throughout the HPA as the result of incidental observations. However, as described above for tailed frogs, much of this HPA is located within young unconsolidated geologic formations. These formations have been shown to have a strong negative influence on torrent salamander occurrence as a result of a lack of suitable stream substrate in these geologic formations (Diller and Wallace, 1996).

3.4.4.12 Rain-on-Snow Areas

The rain-on-snow areas are generally located at elevations above 2,500 feet. Channel and habitat typing assessments have not been conducted in the three rain-on-snow units outside of the 11 HPAs, with the exception of one survey on Elk Creek within the northernmost block. Consequently there is limited information on channel and habitat conditions within these areas.

Green Diamond has conducted surveys of anadromous salmonids within the three rain-on-snow units. The Elk Creek system within the northernmost block (Moore Tract) contains all four salmonids (coho, Chinook, steelhead, and cutthroat trout). The lower portions of tributaries that extend into the Green Diamond ownership in the South Fork Trinity River basin (University Hill Tract) have limited anadromy access, mostly steelhead. Chinook and coho are to be found mostly downstream of the Green Diamond ownership within this same watershed area. It is unknown if salmonids occur within the Supply Creek Tract, although it is known that they are distributed downstream of this third ownership block.

Green Diamond has conducted studies of tailed frogs and southern torrent salamanders to determine their distribution, relative abundance and habitat associations throughout the ownership. These amphibian species have been found at several sites in the rain-on-snow areas.

Little information is available about presence and distribution of the other fish, amphibian, and reptile species covered under Alternative C in the rain-on-snow areas.

3.4.5 Ecological Implications of Land Management Activities on Aquatic and Riparian Habitat, Fish, and Amphibians

3.4.5.1 Background

Understanding the ecological implications of planned land use activities and management commitments on aquatic ecosystems provides a basis for analyzing potential effects of the Proposed Action, other action alternatives, and the No Action Alternative. All land use practices within the Primary Assessment Area and the additional 25,677 rain-on-snow acres under Alternative C could affect aquatic ecosystems to varying degrees. Depending on how land use practices are implemented, their effects could be either adverse or beneficial. Ecological implications and cause-effect relationships associated with past and current land use practices provide a basis for understanding the existing environment and for predicting effects on species and habitat conditions under the alternatives.

These cause-effect relationships generally are well documented in the literature and are considered by most biologists to be relatively common scientific knowledge. The ecological implications and cause-effect relationships are therefore summarized in the following text. A detailed discussion of the potential effects of timber management on covered species and their habitats is also contained in Appendix E of the AHCP/CCAA. Most of the cause-effect relationships apply directly to fish, especially salmonids, and their habitat. However, because the amphibian and reptile species being addressed in this document also depend on functioning aquatic habitat and cool, clean water, the cause-effect relationships described below are applicable to all species covered under the Proposed Action and other alternatives.

3.4.5.2 Historical Management of Aquatic and Riparian Habitat

Prior to 1950, forest harvesting and other timber-related uses along streams and rivers differed little from upslope harvesting: forests were used from the ridge to the stream's edge (Gregory, 1997). Some practices, such as dragging logs and using splash dams to create artificial floods, directly or indirectly delivered sediment to streams, lakes, and estuaries; removed forest canopies and warmed water temperatures; altered forest habitats and reduced future sources of wood inputs; and simplified and narrowed floodplains. On Federal land, production of timber commodities was the primary goal prior to the Multiple Use-Sustained Yield Act of 1960, the National Wilderness Act, and the Wild and Scenic Rivers Act. Prior to 1960, riparian management was not consistently practiced across Federal lands, and no particular protection was identified for riparian areas. Mining for gold and coal on timbered lands also significantly altered rivers and floodplains (Oliver et al., 1994). In addition, there was little or no attempt to restrict grazing in the open range or the effects of water-based recreation.

Prior to the 1930s, grazing and timber harvesting became regulated where public concern for preventing siltation into irrigation reservoirs was raised. Stream channels were straightened to prevent stream bank erosion and control floods (Oliver et al., 1994). For years, standard forest practice was to remove structures from stream channels to improve conveyance. One result of controlled flooding was that roads increasingly encroached on channels and floodplains, often constricting the channel's ability to interact with the floodplains (McIntosh et al., 1994). After 1950, the public and resource managers increasingly expressed concerns over effects of land uses on streams and anadromous salmonids.

There is wide agreement that historical land use practices prior to 1973 adversely affected the structure and productivity of aquatic ecosystems (Elmore and Beschta, 1987; MBTSG, 1998). In 1973, however, passage of the Z'Berg-Nejedly Forest Practices Act by the State Legislature created a framework and multi-disciplinary review process to ensure consideration of riparian and aquatic resource values in the development of timber harvesting plans on State and private lands. The State Board of Forestry, created by the Act, has responsibility for development of forest practice rules (CFPRs), as necessary and appropriate, to protect riparian and aquatic resources. The CFPRs are administered by the California Department of Forestry and Fire Protection. Pertinent examples of CFPRs relevant to fish and wildlife habitat management include: (1) watercourse and lake protection zone rules; (2) special rules to protect fish, wildlife, and watersheds; and (3) rules for defined special treatment areas. (See Section 1.2.2, State Requirements.)

3.4.5.3 Forested Landscapes: Functions and Disturbances

Ecological Functions. The aquatic habitat of greatest interest in the Primary Assessment Area and the additional 25,677 rain-on-snow acres under Alternative C is that which supports, or could potentially support, the eight fish, four amphibian, and one reptile species described above and covered under the various action alternatives. Habitat conditions and requirements important to the survival of these species are numerous, but primarily can be summarized in terms of water quality and the quality and quantity of physical stream habitat available.

Water quality encompasses many attributes, but principally refers to sediment loads and sedimentation within a stream, water temperature and dissolved oxygen levels, and concentrations of nutrients and pollutants. Sedimentation is important because, if it is high, it can embed and reduce the amount of interstitial spaces within the stream substrate. This, in turn, has the potential to limit the production of aquatic insects (food source), suitable spawning areas, and cover areas for fry (salmonids) and larvae (amphibians). Temperature is important because the covered species prefer cool-water conditions and cannot tolerate elevated water temperatures, particularly for extended periods. Nutrients are important in food production, although extreme levels can have some of the same adverse effects on aquatic organisms as pollutants.

Habitat quality (and quantity) primarily refers to the complexity of the stream system and stream flow. Habitat complexity is defined by the type and amount of spawning, rearing, foraging, resting, and overwintering habitat, as well as habitat available for protection from predators. Flows often strongly influence the quantity of habitat available diurnally, seasonally, and among years, and dictate the magnitude and effects of extreme events such as high-flow (scouring) and low-flow (drought) conditions.

Riparian (and potentially upland) areas of forest ecosystems greatly influence both the water and physical habitat attributes of streams and rivers. The degree of influence, whether negative or positive, is generally related to the amount and type of vegetation present and the amount of disturbance from land management activities that occur. Vegetation functions to provide LWD to the stream, canopy closure, bank stabilization, sediment trapping, nutrient inputs (leaf litter and dissolved materials), microclimate, and flow regime modifications. Riparian areas also can act as buffers that prevent or attenuate stream inputs of management-related materials like fine sediment or chemicals applied during forest management. More specific details on these functions are provided in the following sections.

Landscape Disturbances. Ecological functions and processes of forest stands vary as species composition and stand structure change during successional development. Disturbances that alter or interfere with these successional changes have the potential to degrade, reset, or redirect the trend of their ecological functions. Current forested landscapes reflect the effects of climate, topography, and past ecological disturbances.

The primary natural disturbances affecting plant communities are fire, grazing and browsing by ungulates, insect outbreaks and disease epidemics, windthrow, flooding, and erosion (hillslope mass wasting and surface erosion). Most of these processes are altered by human activities. Disturbance, interacting with climate and topography, produces landscape heterogeneity.

Natural and human disturbances have long-term influences on the appearance and composition of forests and the ecological services they provide (Waring and Schlesinger, 1985). Natural disturbance regimes generally provide beneficial ranges of ecological responses, and are required to create and maintain sustainable ecosystems and associated habitats and ecological processes (Everett et al., 1994; Johnson et al., 1994). The historical or natural range of variability is useful for establishing the limits of acceptable change for ecosystem components and processes (Morgan et al., 1994).

Disturbances that do not emulate historical events and disturbance scales, or replace elements required by the ecosystem, can be destructive (Everett et al., 1994). Disturbances caused by timber harvesting can be qualitatively and quantitatively different from natural disturbances; for example, there is no natural analog to disturbances created from road building. Compared to riparian areas with sustained commercial timber harvesting, disturbance patterns in no-cut riparian buffers are more likely to approximate the temporal patterns of natural processes. Repeated harvest activities shift the timing of disturbances from episodic (pulse) events to chronic (press) events.

3.4.5.4 Land Management Activities and Ecological Implications

The following land management activities are commonly associated with timberlands. These activities can potentially impact aquatic habitat, and have been identified in Biological Opinions on Federal land management actions for several listed native salmonids. The activities are silviculture and forest management; road construction, reconstruction, and maintenance; fire management; and recreation and fishing. Because roads are an integral part of forest management activities, the effects of road construction, reconstruction, and maintenance are discussed along with the effects of forest management. Effects of fire management and recreational activities that may affect the quantity and quality of aquatic habitat are discussed briefly following the discussion of forest management.

Spence et al. (1996) described the effects of human activities on watershed processes, salmonids, and their habitats. Chamberlain et al. (1991) summarized four effects of forest management that may modify the hydrologic and geomorphic processes and channel formations that determine the quantity and quality of salmonid habitat. They are:

- Alterations in the hydrologic cycle with potential increases in peak flows or occurrences of channel-forming flows from increased snow-melt or runoff, resulting in increased bed scour and bank erosion
- Increases in sediment supplies from surface erosion, hillslope mass wasting, and bank erosion, leading to channel aggradation, loss of pool volume, and degradation of spawning gravels

- Destabilization of streambanks due to removal of riparian vegetation, physical breakdown, or channel aggradation, resulting in increased sediment supplies and leading to a loss of channel formations that promote a diversity of habitat types
- Loss or reduction of LWD by direct removal, debris torrents, or management practices that convert riparian corridors to younger stands of predominantly hardwoods, contributing to reduced sediment storage sites, and reduced pool numbers and volumes

There has been less research on the potential effects of timber harvesting on amphibian species, but most of the potential effects on salmonids and their habitat are believed to also affect the cool-water adapted stream amphibians. In general, timber harvesting activities have the potential to affect aquatic species (i.e., fish and amphibians) through alteration of one or all of the following processes: hydrologic cycle, sediment inputs and transport, LWD recruitment and distribution, thermal regimes, and nutrient inputs. These and related issues are discussed below under the following headings: effects on the hydrologic cycle, effects on erosion and sedimentation, effects on water quality, and effects on physical habitat.

Effects of Forest Management on the Hydrologic Cycle. The basic components of the hydrologic cycle are precipitation, infiltration, evaporation, transpiration, storage, and runoff. In the coastal areas of northern California, where annual precipitation is highly seasonal, the timing, quantity, and quality of rain and snow fall has great influence on salmonid life histories. Thus, the interactions of timber harvest activities with the hydrologic cycle are important.

Snow Accumulation and Melt. Coastal watersheds of northern California receive most of their precipitation as rain. However, some watersheds in the Primary Assessment Area have upper sections within the transition zone between rain and snow. Along hillslopes in these upper watersheds, the forest canopy intercepts snowfall, redistributes the snow, shades the snowpack, and acts as a windbreak. In these transient areas the snow is generally wet and sticks to the forest canopy longer than colder, drier snow. In transitional areas, snow usually reaches the ground in clumps under trees or as snow melt so that snow pack in forested areas tends to vary in distribution and depth compared to logged hillslopes (Berris and Harr, 1987).

Snow melt from hillslopes in coastal watersheds is usually the result of warmer rainfall or latent heat in air moisture rather than from solar radiation. Snow packs in transitional areas may accumulate and melt several times during the wet season. When the forest canopy has been removed, more of the snow pack is directly exposed to rainfall, warm air, and direct sunlight. Harr (1986) reported there was more heat available to melt snow in a clear-cut stand than in an old-growth Douglas-fir stand during a rain storm with a 2-year recurrence interval. Plot studies in paired watersheds (logged and unlogged) have shown increases in peak streamflow after rain-on-snow events in the logged areas (Harr and McCorison, 1979; Christner and Harr, 1982).

Evapotranspiration and Infiltration. The timber management activities of clearcutting, shelterwood cutting, and precommercial thinning all reduce or eliminate significant amounts of leaves and stems. The surface area of this vegetation normally intercepts precipitation for short-term storage that is either evaporated or released as drip. The loss of forest vegetation also reduces the amount of water extracted from the soil by root systems via evapotranspiration and increases soil moisture and piezometric head. These effects have been demonstrated following harvest of second growth redwood forest (Keppeler and Brown, 1998). These factors may lead to increases in soil water content and in surface runoff. Some studies have reported increases in water yield from logged watersheds (Hibbert, 1967; Harr et al., 1979). These increases were most evident in the start of the fall/winter wet season when rain quickly filled soil pore spaces in the logged areas and then ran off as surface flow (Harr et al., 1979). Differences were less apparent later in the rainy season since soil under mature canopies also becomes saturated, and runoff from logged and unlogged areas became nearly similar (Hibbert, 1967; Harr et al., 1979).

Soil Structure. The soil structure of forested hillslopes regulates the downslope movement of water through the soils and into watersheds. On forested hillslopes the infiltration capacity of the soils usually exceeds rainfall or snowmelt intensities so that all water is absorbed by these soils and transported to stream channels through subsurface pathways (Dyrness, 1969; Harr, 1977). Timber harvest activities that disturb the soil can reduce the infiltration capacity of soils and alter the process of subsurface water movement.

When logging activities compact or disturb surface soils the infiltration capacity is reduced, possibly increasing surface runoff, peak stream flows, and sediment inputs. The compacted surfaces of logging roads and landings are impermeable and water runs off them quickly. Inboard ditches along logging roads not only collect and concentrate surface runoff, but also intercept subsurface flow and bring it to the surface (Furniss et al., 1991). Some studies have shown that forest roads increase peak flows and sediment inputs to small watersheds when as little as 2.5 to 3.9 percent of the watershed is composed of road surfaces (Harr et al., 1975; Cederholm et al., 1981; King and Tennyson, 1984). Conversely, other studies have shown that road construction and some logging activities may have no significant effect on storm runoff (Wright et al., 1990; Johnson and Beschta, 1980).

Effects of Forest Management on Erosion and Sedimentation. Sedimentation is the end result of the erosion of soils in upland and riparian areas that are transported to streams. Erosion is the detachment and movement of soil or rock by water, wind, ice, or gravity (Brady, 1974). Hillslope erosion, sediment delivery, and sediment transport are all naturally occurring processes. The amount and rate of sediment introduced to watersheds is a function of many parameters, including the geology of hillslopes, dominant soil types, climatic conditions, and the occurrence of catastrophic events (floods, fires, earthquakes, or volcanic eruptions).

Timber harvesting and other land use activities can influence upslope erosional processes and how watersheds process sediments. It is important to realize that erosion and sediment transport are "normal" processes and that stream channels are dynamic systems that are constantly changing and adjusting to a variety of inputs. However, timber management activities and road construction, reconstruction, and maintenance, plus exposed soils in the road prism, can accelerate erosion and increase the potential for sediment delivery to streams. The following sections describe the potential impacts that forest management activities, particularly associated with roads, may have on sediment deposition and sediment processing in a watershed.

Sediment Deposition. Eroded materials delivered to streams and deposited on the streambed affect aquatic habitat. The construction, maintenance, and use of forest roads have been indicated as primary sources of sediment impacts in managed watersheds (USFWS, 1998a;

Packer, 1967). Increased levels of fine sediment in streambed gravels have been associated with decreased salmonid embryo survival (Cederholm et al., 1981; Tappel and Bjornn, 1983) and the quality of juvenile rearing habitat (Bjornn et al., 1977). Fine sediment fills the interstitial spaces among gravels and, if severe, can suffocate incubating fish eggs by blocking the flow of water and oxygen to the eggs. Juvenile fish, particularly newly hatched individuals, use interstitial spaces as refugia from high water velocities and predators (Rieman and McIntyre, 1993). Land management that minimizes erosion and sediment delivery to streams addresses this well-documented sensitivity (Chapman, 1988).

Two erosional processes, surface erosion and hillslope mass wasting (landslides and debris flows), are of principal importance on forest hillslopes (Swanston, 1991). Surface erosion in forested watersheds occurs principally through the action of water on the soil surface. Hillslope mass wasting occurs when the force of gravity exceeds the resistive forces that hold the soil on the hillslope, causing mass movement of the soil as a unit. Hillslope mass wasting usually occurs when water accumulates on steep slopes.

Surface Erosion. A common source of sediment input to watersheds is surface erosion. Surface erosion can be a major contributor of sediment in areas where soils are composed of granite or highly fractured marine sedimentary rocks (Furniss et al., 1991). Surface erosion is a two-part process in which particles are first detached and then transported downslope. The two hydrologic processes that transport surface erosion are channelized erosion by constricted flows (rilling and gullying) and sheet erosion in which soil movement is non-channelized (rolling and sliding) (Swanston, 1991). Surface erosion by rainsplash and sheetwash processes from roads (including cut slopes), stream crossings, landings, skid trails, and ditches may all contribute to substantial increases in surface erosion and increased delivery of sediments into stream channels (Reid and Dunne, 1984; Luce and Black, 1999).

Surface erosion occurs on nearly all roads, but the timing and volume of sediment delivery to streams varies with the location and design of the road, ditches, and stream crossings. The delivery rate of road-related sediment to streams is highest where (1) ditches or culverts drain directly to streams, and (2) the distance between the stream and nearby road is insufficient to filter the sediment-laden water (Ketcheson and Megahan, 1996; Megahan and Ketcheson, 1996). Erosion may also occur in association with culvert failures and diversions because of culvert blockages (Piehl et al., 1988; Furniss et al., 1991). Road erosion rates are highest during the first one or two years following road construction, then normally decrease to less than half as much in successive years (Megahan, 1974; WFPB, 1995). Irrespective of their age, roads that receive heavy traffic produce substantially more sediment than low-use or closed roads (Reid and Dunne, 1984; Bilby et al., 1989).

In the past 25 years, studies and reports have shown that road construction for timber harvesting can increase erosion rates within a watershed (Haupt, 1959; Gibbons and Salo, 1973; Beschta, 1978; Cederholm et al., 1981; Reid and Dunne, 1984; Swanson et al., 1987; Furniss et al., 1991). Roads affect watersheds by modifying natural drainage patterns and by accelerating erosion and sedimentation, thereby altering channel stability and morphology. If proper construction techniques and maintenance practices are not followed, sediment increases following road construction can be severe and long-lasting. Gibbons and Salo (1973) concluded that the sediment contribution per unit area from forest roads is usually greater than that contributed from all other timber harvesting activities combined. Recently, techniques have been developed to improve the construction and maintenance of forest roads that minimize erosion and sedimentation (Weaver and Hagans, 1994).

Yarding and skidding activities can also affect the rate of surface erosion. Heavy equipment compacts soils, decreasing infiltration and percolation rates and increasing surface water (Lewis, 1998). The pattern of yarding and skidding can alter drainage paths and redirect water onto areas that may be more likely to erode than naturally evolved channels. Where vegetation and duff are removed, the underlying soils become vulnerable to surface erosion. Burning can also increase erodibility by creating bare ground. The effect of burning on surface erosion depends primarily on the temperature of the burn, soil cover, and soil and vegetation types (Lewis, 1998).

Hillslope Mass Wasting. In steep mountainous terrane, hillslope mass wasting is a major type of hillslope erosion and sediment source in watersheds (Sidle et al., 1985; Swanston, 1991). The frequency and magnitude of hillslope mass wasting is governed by hillslope gradient, level of soil saturation, composition of dominant soil and rock types, degree of weathering, type and level of management activities, and occurrence of climatic or geologic events. Hillslope mass wasting movements are usually episodic events and tend to contribute significant quantities of sediment and organic debris to stream channels over time intervals ranging from minutes to decades (Swanston, 1991). The resultant sediment and organic debris may have a profound effect on a stream channel including large increases in coarse and fine sediments, shifts of existing bed-load, and increases in woody debris that can lead to partial or complete blockages. In extreme situations, debris torrents may scour the existing bed-load of hundreds of meters of stream channel down to bedrock.

Hillslope mass wasting is a naturally occurring watershed process that can be accelerated by human activities. The occurrence of hillslope mass wasting after logging is closely linked to the type and intensity of harvest practices (Rood, 1984; Swanson, 1987). Hillslope mass wasting on logged hillslopes generally result from soil disturbances, increased water content in soils, and decreased root strength of decaying stumps. Numerous studies have reported increases of hillslope mass wasting due to clearcutting ranging from two to 31 times original rates, with an average of 6.6 (Rood, 1984; Ice, 1985; Howes, 1987; Swanson et al., 1987).

Forest road systems and their associated stream crossings in steep coastal watersheds are a major cause of hillslope mass wasting. Cederholm et al. (1981) reported that in Washington’s Clearwater watershed, 60 percent of road related sediment production was from associated hillslope failures and that road surfaces accounted for 18 percent to 26 percent of the sediment production. Roads can lead to increases in the frequency and severity of all types of hillslope mass wasting. Studies in the western Cascades of Oregon by Sidle et al. (1985) reported that hillslope mass wasting associated with forest roads occurred 30 to more than 300 times more often than in undisturbed watersheds. Increases in hillslope failures due to roads are affected by variables such as hillslope gradient, soil type, soil saturation, bedrock type and structure, management levels, and road placement. However, the literature suggests that road placement is the single most important factor because it affects how much the other variables will contribute to slope failures (Anderson, 1971; Larse, 1971; Swanston, 1971; Swanston and Swanson, 1976; Weaver and Hagans, 1994).

Techniques are available to identify hillslopes susceptible to hillslope mass wasting by the use of aerial photography and engineering analysis (Swanson et al., 1987). These measures may be useful in identifying areas where management activities should be avoided or at least conducted in a manner to minimize soil disturbance. Once mass movements have occurred, measures to correct erosion are expensive, time consuming, and rarely successful (Chamberlain et al., 1991).

Sediment Processing. Sediment processing in watersheds consists of the detachment and entrainment of sediment particles by flowing water, sediment transport, and sediment deposition. Once sediment has been delivered to the stream channel its movement through the watershed is governed by numerous factors. These include particle size and shape, amounts of sediment, hydraulic characteristics (frequency and magnitude of elevated flows, size of watershed, and channel gradient), and the occurrence of structures that provide complexity and roughness to channels (boulders, LWD, bedrock, or riparian vegetation).

Sediment is transported as either suspended sediment or as bedload. Suspended sediment consists of fine particles (less than 0.1 mm in diameter) that are entrained in the water column by the turbulence of flowing water. Suspended particles may be transported during a wide range of stream flows. Bedload transport occurs during storms when elevated stream discharge disrupts the armouring layer of the bed, which causes the bed material (particles greater than 1.0 mm in diameter) to roll, slide, or saltate downstream. The downstream transport of bedload is dependent on the magnitude of the stream discharge, channel gradient, and size of bedload particles (Leopold et al., 1964). The flows that initiate transport and sorting of bed material are often referred to as "channel forming flows," have a recurrence interval of approximately 2 to 3 years, and also are the flows responsible for changes in channel morphology.

Timber harvest activities affect sediment processing by increasing sediment supplies, altering the timing and frequency of peak flows, and by changing the channel structure through the reductions of important sediment storage sites provided by LWD (Chamberlain et al., 1991). Additional erosion may occur when stream banks are destabilized and the channel moves laterally and scours bank material (Scrivener, 1988).

Increased sediment delivery to stream channels affects bedload transport mechanisms, channel formations, and aquatic habitats. Increases in bedload can result in increased storage of sediment, which may lead to decreases in the number and depth of pools, a widening of the channel, and destabilization of stream banks (Everest et al., 1987). The effects of increased sediment can be short lived or persistent, depending on the amount and duration of the sediment source. Using a bedload and transport and routing model, O'Conner and PWA (2001) reported that a period of decades is required for gravel size material to be transported from the upper Freshwater Creek watershed to the lower watershed. Sand-size material is probably routed from source areas to lower Freshwater Creek over a period of about a decade. Hartman et al. (1987) reported that on Carnation Creek sudden pulses of fine sediment tended to be processed within several years, provided the watershed was not overloaded with sediment and that the erosional sources were healed. However, a channel subjected to continuous and persistent increases of sediment may become braided at low flows with much discharge occurring as sub-surface flow, and as a wide shallow channel at high flows that has a reduced capacity to transport elevated discharges. Continuous inputs of fine sediments also may infiltrate deeply into the channel bed and can persist for many years (Swanston, 1991).

Effects of Forest Management on Water Quality. Primarily, four aspects of water quality can be affected by forest management activities:

- Sedimentation
- Water temperature
- Dissolved oxygen levels
- Contaminant levels

Sedimentation. The amount of sediment deposition in a stream depends on the availability of sediment through erosion, and the rate of sediment delivery to the stream. Generally, the amount of sediment created from timber management activities is related to the amount of bare and compacted soils that are exposed to rainfall and runoff. Slope steepness, slope storage capacity, and proximity to stream channels determine the rate of sediment delivery (Quigley and Arbelbide, 1997). Activities such as skidding and yarding can compact soils because of the machinery used, especially at landings. Skidding generally causes more ground disturbance than cable or helicopter yarding. However, cable yarding on steep slopes also may result in soil disturbances because the ends of trees may drag on the ground, scarring and exposing soil.

Logging activities of timber harvesting, site preparation, and road construction may increase the amount of suspended sediment within a watershed. The amounts vary seasonally, but logging activities can alter the amount, timing, and duration of suspended sediments. Most studies have shown that roads are the main sources of suspended sediment associated with timber management activities (Anderson, 1971; Cederholm et al., 1981; Furniss et al., 1991; Swanston, 1991). The effect of roads on sediment inputs were described above.

Laboratory studies have revealed the negative effects of suspended sediment on developing salmonid eggs and embryos, yet results from field experiments have been less conclusive (Everest et al., 1987). Newcombe and MacDonald (1991) provided an extensive review of more than 70 studies that attempted to document the effects of suspended sediment on aquatic organisms. Their conclusion is that there is little agreement on the environmental effects of suspended sediment as a function of concentration and duration of exposure (Newcombe and MacDonald, 1991).

Water Temperature. All life stages of the covered species noted above require relatively cold to cool water. Suitable stream temperatures are maintained through a variety of mechanisms. In general, surface water temperatures are related to local air temperatures, except where influenced by groundwater. The primary factors affecting air temperature are elevation, aspect, latitude, humidity, wind, and sunlight. Stream temperatures also are affected by stream gradient, stream flow, and water source (groundwater, snowmelt, or rain). Tree removal generally reduces shade and humidity, and increases wind velocities and stream flow. A reduction in tree density and canopy closure in areas adjacent to streams might also affect stream temperature by allowing changes in microclimate variables, including increased air temperature, lower humidity, increased wind speed, and increased ground temperatures. Sediment input, particularly increases in fine sediment, can affect stream temperatures through changes in channel input morphology such as reduced pool volume and increased channel width (Rhodes et al., 1994; Lewis, 1998).

The principal source of heat for small mountain streams is solar radiation striking the surface of the stream (Brown, 1969). Flow can be affected if the removal of large areas of vegetation reduces the amount of surface water infiltration into the soil because of compaction (Chatwin et al., 1994). Although reduced infiltration is not directly related to temperature, the amount of groundwater reaching a stream over time can be affected. The temperature of groundwater is usually close to the average annual ambient air temperature of a region.

Water temperature increases resulting from timber harvesting are greatest during the low-flow periods in summer and early fall. During low flow, groundwater comprises most of the stream flow because input from other sources such as snowmelt has declined. Also, the travel time for water through a given stream reach is longer (because velocities decrease with decreasing flow), exposing the water to more solar radiation. Reductions in canopy cover because of timber harvesting could worsen this condition (Beschta et al., 1987).

Reductions in canopy cover may also decrease temperatures in late fall or early winter. Tree canopies moderate heat loss from streams when the air temperature is cooler than the water. A reduction in canopy cover accelerates heat loss, with the greatest effect on small streams, and little or no effect on wide rivers. Before ice begins to form on streams in late fall and early winter, rapid decreases in stream temperatures can occur during the night.

Changes in water temperatures from the removal of riparian vegetation may benefit or negatively impact salmonid populations. Among the potential benefits is a short-term increase in primary and secondary production that would increase the amount of available food. Studies have shown that after logging, increases in filamentous algae promoted the abundance of invertebrate grazers such as baetid mayflies, grazing caddisflies, and midges that were more likely to contribute to the insect drift and be available as food for salmonids (Hawkins et al., 1982).

Increased water temperatures during summer months as a result of logging can have negative impacts on salmonids (Beschta et al., 1987). These impacts can result in increased stress, and even death, during rearing; prevention or delay of upstream migration by adults; reduced resistance to diseases; poor growth of juveniles due to reduced metabolic efficiency; and shifts in the competitive advantage of salmonids over non-salmonid species (Hallock et al., 1970; Hughes and Davis, 1986; Reeves et al., 1987, Spence et al., 1996).

Dissolved Oxygen. Dissolved oxygen levels in forest streams are generally not a significant source of mortality for adult salmonids, but oxygen limitations can cause mortality while eggs and fry are in the gravels. Dissolved oxygen levels decline when water temperatures increase and stream flows decline. As water warms, it loses its capacity to hold or retain dissolved oxygen; at low flows, the surface mixing of water and air is minimal. A substantial reduction in canopy cover (shade), therefore, has the potential to reduce dissolved oxygen levels in streams if stream temperatures become elevated. Increased nutrient levels also can reduce dissolved oxygen levels by increasing the biological oxygen demand in the water. Tree removal near streams may result in nutrient loading through soil disturbance and the input of organic material. However, nutrient levels quickly return to normal levels following harvest activities (Chamberlain et al., 1991, in Quigley and Arbelbide, 1997). Hicks et al. (1991) concluded that there was no evidence of a major effect of logging on salmonids due to low dissolved oxygen concentrations in surface water.

Contaminants. Most aspects of forest management require the use of mechanized equipment. Where machinery is used, there is the potential for contamination of stream waters through accidental spills of fuels, oils, and other toxic materials. The potential risk and magnitude of pollution is related to the location and duration of the activity. Landings near streams have the greatest potential to deliver pollutants to streams because they are areas of concentrated activity. The application of pesticides, herbicides, and fire retardant also has the potential to introduce pollutants to streams. These contaminants are most likely to be introduced as aerosols and as chemicals are released through runoff from precipitation.

Forest practices can lead to changes in nutrient distribution and dynamics in upland areas, which in turn affect availability in streams (Spence et al., 1996). Harvest intensity (i.e., the proportion of forest canopy removed), type of harvest, and cutting frequency all affect the rate of nutrient removal from the system (Beschta et al., 1995). Despite the loss of nutrients stored in removed biomass, nutrients are generally more available to stream organisms in the years immediately following harvest (Spence et al., 1996). The addition of slash to the forest floor (Frazer et al., 1990), accelerated decomposition of organic litter resulting from increased sunlight reaching the ground (Beschta et al., 1995), and increased water availability for leaching of materials, increased surface runoff and erosion that contributes nutrients to the stream environment (Gregory et al., 1987) are largely responsible for this increase. As soils stabilize and revegetation occurs, the rate of nutrient input typically declines (Spence et al., 1996).

Studies have shown increases in plant nutrients (inorganics such as nitrogen, phosphorus, potassium, calcium) after logging, but these increases were shown to be moderate and for short time periods (Brown et al., 1973; Scrivener, 1982). The nutrient enhancement coupled with increases of solar radiation usually lead to increases in autotrophic production and possible increases in invertebrate grazer populations (Gregory et al., 1987). However, it is inconclusive if salmonid populations respond in either increased growth or numbers to nutrient increases (Gregory et al., 1987).

Effects of Forest Management on Physical Habitat. Harvesting trees causes changes in forest structure and landscape composition. Tree removal in riparian corridors reduces the potential for input of LWD and organic matter to a stream, and can reduce bank stability if trees are removed near the stream bank (Swanson et al., 1987; MBTSG, 1998). These changes have the potential to alter channel morphology and reduce stream habitat complexity. Water removal and culverts can also influence the quantity of available habitat and the ability of fish to move between habitats.

Large Woody Debris. Riparian areas provide numerous ecological functions that support aquatic ecosystems. Thinning and harvesting of timber in riparian areas reduces the availability of LWD that enters streams. In the past, timber harvesting has resulted in reductions of in-channel LWD and potential LWD by extensive clearing of stream channels, removal of most large conifers from the riparian zone, and short-rotation timber harvesting. These activities have altered the sources, delivery processes, and redistribution of woody debris in watersheds and have impacted the abundance and distribution of Pacific salmonids (Bisson et al., 1987; Maser and Sedell, 1994).

LWD provides complexity by adding woody cover or facilitating the creation of hydrologic features such as pools, gravel bars, and backwater areas. In small streams, gravel bars created by log jams or single pieces of LWD are sometimes the only suitable spawning gravels for long distances. Pools and backwater areas provide cover by virtue of deep water and provide refugia from high stream flows. These areas often are critical to the juvenile lifestage of salmonids and other fish species. Amphibians may also utilize pools and backwater areas during one or more life history stages. LWD provides nutrients to a stream as well as a substrate for aquatic invertebrate (insect) production (Bisson et al., 1987; Montgomery et al., 1996).

Bank Stability. Tree removal near streambanks may increase the potential for bank erosion, which can result in the loss of underbank habitat and decreased water depth. Many salmonid species, particularly adults, use undercut banks as holding habitat and feeding stations. Undercut areas provide fish refugia from main channel velocities, overhead cover from predators, and a place to feed on drifting aquatic and terrestrial insects and smaller fish. Undercut banks form when soils are scoured beneath vegetation or roots that hold the surface soils intact. Removal of trees along streambanks can eliminate or reduce the potential for this type of habitat. The root systems of trees near the banks also provide channel stability during periods of high flow, and reduce the potential for floodplain and streambank erosion (MBTSG, 1998).

Water Removal. Pumping and transporting water from streams for watering roads can potentially have adverse effects because of reduced stream flows and the entrainment of organisms, unless water intakes are appropriately screened. Reductions in stream flows during late summer and early fall are particularly important because stream flows are naturally low during this time of year. Fish that become entrained are essentially lost to the population.

Culverts. Culverts designed and built for water passage can be a barrier to fish movement. Culverts with an opening larger than necessary may create water depths too shallow for fish passage, especially during low-flow periods. Depending on the water velocity, extremely long culverts may preclude fish passage since fish cannot sustain high swimming speeds for long periods of time (Bell, 1986). Culverts with high slopes may create velocities during certain flows that are impassible by fish, regardless of culvert length. The last aspect of culverts is drop, which is the vertical distance from the discharge of the culvert into the stream. Depending on the distance, drop may preclude small fish from passage and even discourage larger fish from attempting passage (Bell, 1986).

Effects of Fire Management. To reduce fire hazards, fire prevention involves silvicultural practices such as thinning, salvage, and prescribed burning, and the construction of barriers such as fire breaks. Fire control involves mechanical and chemical methods of fire suppression.

Fire prevention and control, particularly from activities in or near riparian corridors, have the potential to affect several aquatic habitat functions. Examples of these effects include the following:

- Removal or reduction of LWD, which could reduce habitat complexity and alter stream channel configuration.

- Reduction in stream canopy cover, which could increase stream water temperatures.
- Promotion of hillslope mass wasting and surface erosion through the reduction of surface vegetation. This could cause increased surface erosion and sedimentation of streams, which could alter peak and low flows if it occurs over a large area.
- Use of chemical retardant to fight wildfires, which can kill fish and amphibians if applied on and near streams in sufficient quantities. There is also the potential for mortality of aquatic invertebrates and the increased nutrient input to downstream reaches, which could result in indirect effects of fire retardant on aquatic species.
- Fire plow lines and soil scarification, which could increase stream sedimentation.

Effects of Recreation and Fishing. Important values of most aquatic ecosystems are the recreational and fishing opportunities they provide. Maintenance of high-quality recreation values for many rivers, streams, and lakes is often a natural resource management goal of resource agencies. However, recreation and fishing activities can adversely affect fish populations and aquatic habitats as described below.

Introduction of Non-Native Fish Species. The introduction of non-native fish species is usually intended to create or expand fishing opportunities, but instead can adversely affect the native fish community. This can occur through specific species interactions, including competition, predation, and hybridization. Competition occurs over a wide range of ecological situations when two or more organisms compete for the same limited resource. It includes physical competition between individuals (Chapman, 1966), and niche specialization where one species is more efficient at using a habitat than another (Miller, 1967). Predation includes predation on one species by another, and predation by larger (older) fish on smaller ones of the same species. Hybridization and genetic introgression includes reproductive crosses between species that result in changes to the gene pool of one species (such as cutthroat trout/rainbow trout hybrids or introduction of genetic material from hatchery fish). All three interactions may affect native fish populations simultaneously.

Legal Fishing. Legal fishing has the potential to adversely affect local populations of native salmonids, primarily through incidental catch and habitat alteration. Incidental catch can result in unintentional angling mortality through wounding, stress, or the misidentification and unintentional harvest of some species. Wading by anglers can trample spawning redds and increase bank erosion. Trampling can result in the direct mortality of incubating fish eggs and recently emerged fry, while increased bank erosion can accelerate habitat degradation.

Illegal Fishing. One of the most detrimental activities on some species is illegal fishing or poaching. Laws and regulations are developed for certain species to protect sensitive life stages such as spawning adults, certain local populations that are depressed, or, in the case of threatened species, to prevent extinction. Poaching can severely impact fish populations by further reducing populations or sensitive life stages that are already depressed, and by directly killing individuals of a species.

Foot Traffic. Foot traffic can damage vegetation along lakes and streams, either directly through trampling or indirectly through soil compaction. Vegetation damage can lead to erosion and sedimentation, depending on the amount of activity, and can accelerate habitat degradation. Foot traffic through areas used for spawning (fish) or reproductive activities (reptiles and amphibians) can impact these species through disturbance of essential reproductive behaviors. Trampling of spawning redds can result in the direct mortality of incubating fish eggs and recently emerged fry.

Off-Road Use of Recreational Vehicles. The effects of off-road recreational vehicle use can alter plant community structure and create gaps in vegetation along shorelines and streams (Quigley and Arbelbide, 1997). The partial loss of vegetation can increase erosion along waterbodies. Also, use of off-road vehicles in streams may result in the direct destruction of redds, eggs, and possibly young fish.

3.5 Vegetation/Plant Species of Concern

3.5.1 Introduction

This section relies on data made available from Green Diamond, the California Natural Diversity Database (CNDD), CDFG, and USFWS. Data has been collected, assessed, and simplified for purposes of this EIS. This chapter describes vegetation contained within the coverage area for the Proposed Action and other action alternatives, as well as for all of the Green Diamond fee-owned lands within the Primary Assessment Area in northern California. Vegetation has been grouped into habitat type classifications. The frequency, composition, and spatial distribution of habitat types within Green Diamond's fee ownership within the Primary Assessment Area and the general character of the Primary Assessment Area have been characterized by data provided by Green Diamond.

Green Diamond uses a cover type classification system that focuses on merchantable timber for timber management purposes. Aerial interpretation and ground-truthing is performed according to the established criteria of this system. Biologists at Green Diamond have recently developed a computer algorithm that converts the merchantable timber cover type classification system into the California Wildlife Habitat Relationships (CWHR) System (Mayer and Laudenslayer, 1988). The CWHR system was used in this analysis to identify potential wildlife use within the Green Diamond ownership and to compare existing conditions with future wildlife habitat trends under each project alternative. The current habitat conditions are described below according to CWHR, with the exception of "bare land" and "unclassified," which are classes defined by Green Diamond. The habitat codes, size classes, and canopy closure classes in the CWHR system are defined in Table 3.5-1.

Unclassified land represents either areas that Green Diamond has never surveyed, since most of these areas are lands where some other entity has cutting rights, or lands not located within an HPA and not classified as rain-on-snow. Bare lands are areas where vegetation is absent, for any one of a number of reasons. These lands are mostly a collection of bare rock outcrops, major landslides, and rock pits (i.e., areas being mined for rock to use on roads).

The model used by Green Diamond biologists to convert Green Diamond timber type maps to CWHR classification has not been field-tested and is intended for general characterization purposes only. The classifications derived from the model are based on larger scale habitat characteristics; that is, small inclusions of a particular habitat type may be generally incorporated into another CWHR classification. Further, it is possible that some of the habitat within an HPA on the Green Diamond ownership is identified as Montane Riparian

TABLE 3.5-1
Definitions of CWHR Habitat, Size, Class, and Canopy Closure Class Codes

Habitat Codes	Definition
MHW	Montane Hardwood
CSC	Coastal scrub
DFR	Douglas-fir
MHC	Montane hardwood/conifer
RDW	Redwood
KMC	Klamath Mixed Conifer
LAC	Lacustrine
RIV	Riverine
UNCL	Unclassified
WTM	Wet Meadow
URB	Urban
BARE	Bare land
PGS	Perennial Grassland
Size Classes	**Definition**
1	Stand has a quadratic mean diameter of < 1 inch
2	Stand has a quadratic mean diameter of 1 to 5.9 inches
3	Stand has a quadratic mean diameter of 6 to 10.9 inches
4	Stand has a quadratic mean diameter of 11 to 23.9 inches
5	Stand has a quadratic mean diameter of 24 to ≥ 32 inches
6	Stand has Size Class 5 trees over a distinct layer of Size Class 4 or Class 3 trees; total canopy closure is at least 60 percent
Canopy Closure Classes	**Definition**
S (sparse)	Stand has 10 to 24.9 percent total canopy closure
P (open)	Stand has 25 to 39.9 percent total canopy closure
M (moderate)	Stand has 40 to 59.9 percent total canopy closure
D (dense)	Stand has 60 to 100 percent total canopy closure

habitat. The algorithm is not able to distinguish this habitat type from other forest habitat types. Therefore, no Montane Riparian habitat has been identified in the data presented below. For the most part, Green Diamond does not have these narrow riparian zones mapped as distinct polygons in their geographic information system (GIS). As a consequence of the fact that much of Green Diamond's property would qualify as a temperate rainforest, the riparian vegetation is not significantly different from the surrounding forest across much of the area. The distinctly unique riparian areas present within the ownership are either rare enough, or small enough, such that Green Diamond has not delineated them. The areas that have been classified as Riverine as opposed to Riparian, are legitimate riverine areas, consisting of large enough bodies of flowing water and their associated beds/bars (submerged in winter; exposed in summer). These areas have been typed out as polygons that are classified in the system as "non-forested waterways." While the CWHR classifications derived from the computer algorithm may be imprecise, they are sufficient for characterizing the Green Diamond ownership and for determining potential impacts from action and no action alternatives.

Sensitive plant species potentially occurring within the Primary Assessment Area and the Green Diamond ownership were identified by the following sources: the CNDD, Green Diamond observations, and discussions with USFWS and CDFG. Information from the CNDD was made available via regularly updated computer software called RAREFIND. Sensitive species lists were generated for each of the USGS 7.5′ quadrangles (over 50 quadrangles, one million acres) containing the 11 HPAs and Green Diamond's California ownership outside the HPAs, which is predominately rain-on-snow areas. This information was then entered into an ACCESS database to associate species occurrence by HPA (or by USGS quadrangle if outside the HPAs).

3.5.2 Regional Setting

3.5.2.1 General Vegetative Character

Productive soils, moderate temperatures, and seasonally abundant moisture support a mixed cover of dense forest and prairie vegetation within the Primary Assessment Area. Redwood is the dominant tree on the relatively moist flood plains, low stream terraces, and lower hillslopes adjacent to the main channel. On the upper slopes, Douglas-fir is the dominant conifer associated with western hemlock, tanoak, and Pacific madrone.

Areas of natural prairie and woodland vegetation are intimately associated with forested areas throughout much of the Primary Assessment Area. The most common communities of nonforest vegetation are grass prairies, grass-bracken-fern prairies, oak-grass woodlands, oak-poison oak-grass woodlands, and oak-madrone-brush woodlands. The origin of the grass and grass-bracken-fern prairie is partly the result of hillslope mass wasting, natural fires and fires set by local Native American tribes, and lateral variability in soil parent materials (Swanston et al., 1995).

Eleven CWHR habitat types are present within the Green Diamond ownership. While it is unlikely, more habitat types may be present within the "Primary Assessment Area" that comprises the current ownership and lands that may be acquired by Green Diamond in the future. In addition to the 11 CHWR habitat types, Green Diamond has included two classifications to describe land cover within its ownership, including Bare Land (Bare) and Unclassified Land. Of the 13 habitat types that are present, however, only 5 are forested: Montane Hardwood (MHW), Klamath Mixed Conifer (KMC), Douglas-fir (DFR), Redwood (RDW), and Montane Hardwood Conifer (MHC). Five non-forested vegetative habitat types that are present and intermixed with the forested habitat types are Perennial Grassland (PGS), Wet Meadow (WTM), Riverine (RIV), Lacustrine (LAC), and Bare. Other non-forested habitat types that are present within the Green Diamond ownership include Coastal Scrub (CSC), Urban (URB), and Unclassified Land. CSC, URB, and Unclassified Lands are not generally associated with commercial timberlands. They are, therefore, not included in the Action Area or Primary Assessment Area (see Section 3.1), and not described or analyzed in detail in this EIS. Table 3.5-2 provides a breakdown of the distribution and abundance of the forested and non-forested habitat types within the Green Diamond ownership. Figure 3.5-1 provides a graphic display of the habitat types within the Green Diamond ownership as distributed throughout the 11 HPAs.

More than 96 percent of the Green Diamond ownership is forested, with RDW being the most common forest habitat type. RDW is also the most common habitat type of all habitats present. It represents about 55 percent of the acreage found within forested habitat types. RDW is followed in percent composition by DFR (18.7 percent), MHC (13.7 percent), and MHW (9.1 percent). KMC only accounts for about 26 acres. KMC is only found in the rain-on-snow areas of Green Diamond’s ownership. RDW, DFR, MHW, and MHC are found in all 11 HPAs. DFR, KMC, and MHW are found primarily within the eastern portion of the Green Diamond ownership. Whereas, as expected, RDW and MHC are found primarily along the western portion, or closer to the coast. MHC is found only in the northwestern portion of the Green Diamond ownership.

The primary hardwood species that are represented within the MHW and MHC habitat types are red alder, tanoak, Pacific madrone, Oregon white oak, and black oak. Red alder is the dominant overstory species in the riparian areas. Tanoak and Pacific madrone occur along ridge lines and mid-slope areas and are intermixed with conifers. Oregon white oak and black oak occur in the drier transition zones between Douglas-fir forests and prairies.

A long history of logging in the region has resulted in a mixture of even-aged stands. Using GIS data and CDFG’s CWHR criteria, the general stand composition and structure within the Green Diamond ownership were determined. Approximately 12 percent of the Green Diamond ownership within the 11 HPAs and the rain-on-snow areas is characterized by age classes greater than 60+ years. Most of the older vegetation is located within the Coastal Lagoons and Mad River Hydrographic Areas and the Little River Hydrologic Unit (see Figure 3.5-2). Other, general regional characteristics include:

- About 64 percent of the Green Diamond ownership within the 11 HPAs and the rain-on-snow areas is classified as CWHR size class 1-3
- Approximately 29 percent of the Green Diamond ownership within the 11 HPAs and the rain-on-snow areas is forest habitat classified as CWHR size class 4, stands with an average diameter at breast height (dbh) between 12 and 24 inches
- More than 63 percent of the forested habitat within the Green Diamond ownership within the 11 HPAs and the rain-on-snow areas has dense canopy closure

TABLE 3.5-2
Percent Composition of Habitat Type Within Green Diamond Ownership

	Acreage Distribution in Hydrographic Planning Areas												
CHWR Classification	**Smith River**	**Coastal Klamath**	**Blue Creek**	**Interior Klamath**	**Redwood Creek**	**Coastal Lagoons**	**Little River**	**Mad River**	**N. Fork Mad River**	**Humboldt Bay**	**Eel River**	**Non-HPA (rain-on-snow)***	**Total Ownership Acreage**
Montane Hardwood	4.64%	3.42%	4.62%	27.82%	15.86%	0.24%	0.84%	13.51%	4.59%	0.20%	0.92%	9.92%	9.13%
Klamath Mixed Conifer	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.01%
Douglas-Fir	15.06%	6.19%	9.37%	33.13%	34.14%	11.75%	7.72%	22.23%	22.63%	2.06%	4.85%	43.84%	18.74%
Redwood	55.06%	81.36%	77.80%	10.61%	33.05%	86.08%	86.24%	40.15%	51.90%	96.32%	92.90%	0.49%	54.75%
Montane Hardwood Conifer	20.26%	6.25%	2.88%	25.16%	14.50%	0.55%	4.84%	12.60%	18.37%	0.42%	0.07%	44.57%	13.74%
Riverine	1.09%	0.55%	3.55%	0.21%	0.69%	0.22%	0.00%	1.42%	0.74%	0.00%	0.71%	0.12%	0.67%
Bare	0.01%	0.05%	0.09%	0.08%	0.08%	0.40%	0.17%	0.09%	0.05%	0.07%	0.01%	0.18%	0.11%
Coastal Scrub	3.33%	1.98%	1.53%	1.38%	0.22%	0.63%	0.02%	0.25%	0.08%	0.32%	0.07%	0.04%	1.11%
Perennial Grassland	0.14%	0.06%	0.16%	1.59%	1.10%	0.04%	0.17%	9.75%	0.47%	0.61%	0.47%	0.73%	1.56%
Wet Meadows	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Urban	0.34%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.17%	0.00%	0.00%	0.00%	0.14%
Unclassified	0.06%	0.00%	0.00%	0.00%	0.34%	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%
Lacustrine	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

* Green Diamond ownership outside of the 11 HPAs

3.5.2.2 CWHR Classifications

Klamath Mixed Conifer. The KMC habitat type is restricted to the Klamath region of northern California and southwestern Oregon. It occurs along the eastern boundaries of Del Norte and Humboldt counties at elevations from 4,500 to 7,000 feet, often on steep slopes or in narrow valleys. While very similar to the mixed conifer type, it is distinguished by its higher species diversity. Douglas-fir and white fir are the dominant tree species, with Shasta red fir, lodgepole pine, Jeffrey pine, mountain hemlock, western white pine, Brewer spruce, canyon live oak, and black oak also included in the community. The understory is comprised of a rich shrub layer including: chinquapin, Sierra laurel, Saddler oak, dwarf rose, manzanita, huckleberry, oak, snowberry, and Oregon grape, as well as a well-developed and diverse herbaceous layer.

Following disturbance, a dense community of montane chaparral develops from seeds in the soil seed bank. If adequate seed sources are present, a dense stand of young conifers follows the shrub stage within 20 to 30 years. The successional stages are often dependent on the type and frequency of disturbance as well as site-specific environmental factors. The communities are considered to be relatively well adapted to low intensity fires; however, intense or frequent fires may result in continued dominance of the montane chaparral type.

KMC represents less than 26 acres of the Green Diamond ownership, and is found only in the rain-on-snow areas. All habitat present has been classified as KMC1P (size class 1, open).

Douglas-Fir. The DFR type is widespread throughout northwestern California, including Del Norte and Humboldt Counties, at elevations ranging from 500 to 2,000 feet. Douglas-fir is the characteristic dominant species and associated species of conifers and hardwoods vary depending on soils, moisture, topography and disturbance history. On dry, steep slopes, canyon live oak is frequently abundant, but other trees, shrubs and herbs are sparse. In moderately dry areas, tanoak, Pacific madrone, sugar pine, ponderosa pine, and black oak are common components of the canopy, with Oregon grape, California blackberry, dwarf rose, and poison oak occurring in the shrub layer. Forbs and grasses include Pacific trillium, western swordfern, insideout flower, broadleaf starflower, deer vetch vanillaleaf, bracken fern, western fescue, common beargrass, and whitevein shinleaf. On the wettest sites, Port Orford cedar and Pacific yew are present in the canopy and common shrubs include vine maple, California hazel, and Pacific rhododendron.

Following disturbance, resprouting tanoak typically dominates with various other shrubs and forbs. In moist areas where young Douglas-fir is present in the tanoak community, the shrubs are generally overtopped by the trees in 15 to 30 years. The shrub community may persist for 60 to 100 years on dryer sites. Snags and downed logs, an important structural component of this habitat, increase in density or volume with stand age. In the absence of fire or other disturbance, western hemlock may occur as a codominant with Douglas-fir and tanoak in areas transitional to redwood forests. In the absence of disturbance, climax stands typically develop in 80 to 250 years.

DFR represents about 18.7 percent of the Green Diamond ownership within the 11 HPAs and the rain-on-snow areas, with about 82,848 acres recorded. Most of this acreage (26 percent) is found in the Interior Klamath HPA. This habitat type is also abundant in the Redwood Creek Hydrologic Unit and Mad River Hydrographic Region. Nearly 60 percent of the DFR habitat type is found within the eastern portion of the Green Diamond ownership. Very little of the DFR habitat type is found within the Humboldt Bay and Eel River HPAs located in the southern portion of the Green Diamond ownership (360 and 384 acres, respectively). About 71 percent of this habitat type is characterized as size class 1 through 3, with the remaining 29 percent characterized as size class 4 through 6. Size class 6, however, accounts for less than 1.0 percent of the DFR habitat. Size class 1 is the most abundant, accounting for about 35 percent of this habitat type. The next most abundant class (31 percent) is class 3. About 59 percent of this habitat type is characterized as having a dense canopy.

Redwood. The RDW habitat type refers to the mixed conifer forests that occur in the moist coastal environments at elevations ranging from sea level up to 3,000 feet. Redwoods are found throughout this range, but are only dominant in a narrow band within ten miles of the coast. Further inland, Douglas-fir becomes the dominant canopy species. Common associated species include sitka spruce, grand fir, Pacific madrone, and tanoak. Western red cedar and western hemlock are present, but are not significant species in the canopy. The moist climate and fertile soils result in a generally lush understory growth of shrubs, ferns, herbs, and grasses. Common understory species include barbary salal, coast rhododendron, ocean spray, huckleberry, snowbrush, ceanothus, sword fern, deer fern, and salmonberry.

This habitat type typically recovers rapidly from disturbance. Within 10 years, the early herbaceous vegetation is replaced by shrubs and redwood sprouts. Within 30 to 60 years, the shrub stage is followed by a mixture of conifers and hardwoods, with persistent shrubs remaining in the understory. A mature stand, dominated by redwoods with a second canopy layer of Douglas-fir requires at least 150 years to develop.

RDW represents about 55 percent of the Green Diamond ownership in the 11 HPAs and the rain-on-snow areas, with 241,973 acres recorded. Most of this acreage (nearly 30 percent) is found in the Coastal Klamath Hydrographic Region. The Coastal Lagoons Hydrographic Region contains another 14 percent of this habitat type. Redwood is least common in the Interior Klamath Hydrographic Region and the rain-on-snow areas. While only 3.0 percent of the total RDW type is found within the Eel River Hydrographic Region, RDW accounts for almost 93 percent of the habitat found within this HPA. About 58 percent of the RDW habitat type is characterized as size class 1 through 3, with the remaining 42 percent characterized as size class 4 through 6. Size class 6 accounts for less than 1 percent of the RDW habitat type. Size class 4 is the most abundant, accounting for approximately 37 percent of this habitat type. The next most abundant class (35 percent) is class 4. Almost 59 percent of the RDW habitat type within the Green Diamond ownership is qualified as having a dense canopy.

Montane Hardwood Conifer. The MHC habitat type occurs throughout California and occurs extensively in both Del Norte and Humboldt counties on coarse, well-drained soils, at elevations ranging from 1,000 to 4,000 feet. This habitat type is a transition between the conifer dominated forests and the montane hardwood and is distinguished by having at least a third of the canopy species comprised of hardwoods and at least a third conifers. Typical canopy species include ponderosa pine, Douglas-fir, incense cedar, black oak, tanoak, Pacific madrone and golden chinquapin.